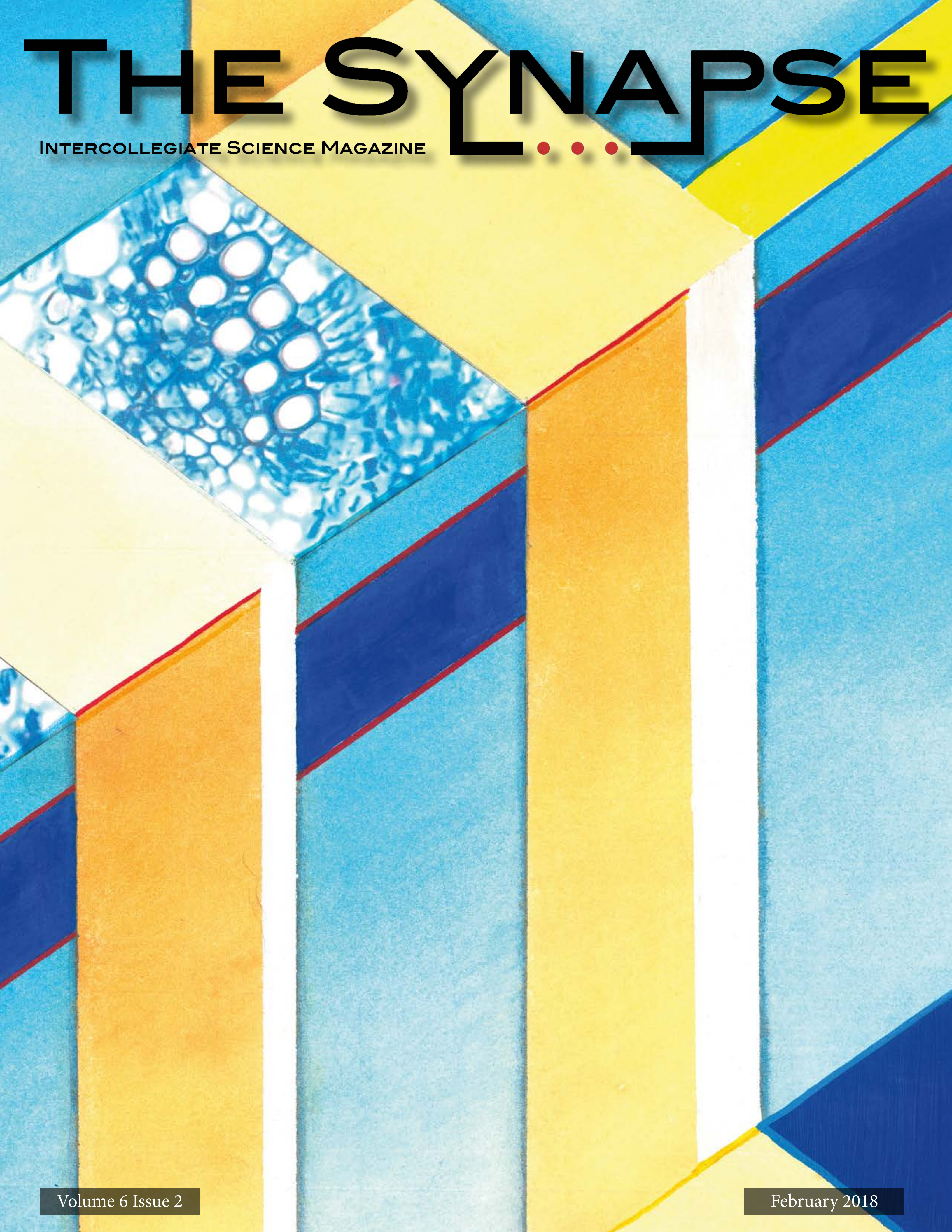
The Synapse

Intercollegiate Science Magazine



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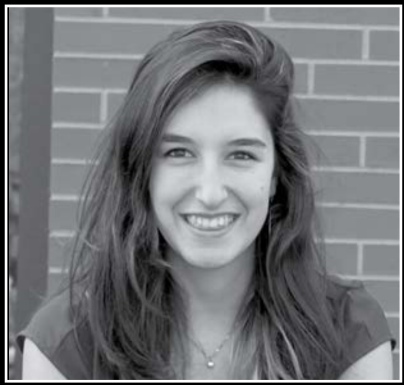
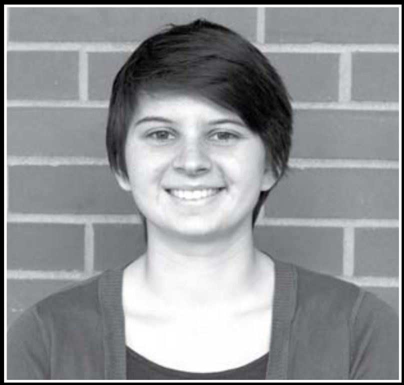




Climate Change.

Two simple words that not only provoke extreme reactions in human beings—they describe extreme instances in natural weather patterns over time. Across the country and around the world, natural disasters are having more and more acute effects on people, animal populations, and landscapes. In 2017, the United States alone suffered raging wildfires on the West Coast, at least two major hurricanes in the Gulf of Mexico, and whirlwind blizzards in the Northeast and Midwest. Regardless of the time of year or region, thousands of people—low-income persons especially—bear the consequences of these disasters, whether through loss of material goods, displacement, or even death.

The western United States was devastated by over 50,000 individual wildfires in 2017; at least 100,000 people have been displaced. Flooding from Hurricane Harvey killed 82 people at the last count. The majority of Puerto Ricans remain without running water and electricity in their homes and businesses, even five months post-Hurricane Maria. Sub-zero temperatures and dramatic snowfall in the early days of 2018 virtually shut down major cities and towns in the north.

While no individual extreme weather event can be attributed directly to climate change, the increased impact of these natural disasters are caused by climate change. The increased rainfall that caused such dramatic flooding in Houston and Puerto Rico was the result of higher moisture content in warmer air over the Gulf Coast. Warmer sea surface temperatures made already drastic tropical winds in those hurricanes more savage, leaving behind billions of dollars in damages. Earlier snowmelt due to spring and summer warming has contributed to the rapid spread of western wildfires. All of these seemingly small changes have added up to some of the most damaging natural disasters in U.S. history; and while evidence supporting the manifold impacts of climate change should inspire more of a focus on understanding and reversing anthropogenic global warming trends, the steady stream of employees leaving the Environmental Protection Agency since 2016 clearly points to other priorities in the current presidential administration. To learn more about climate change and its influence on U.S. environmental legislation in this issue, check out Leo Lasdun's article: *What's Cooking?*

As with most student publications, *The Synapse* and the dedicated contributors, administrators, and advisors that keep it running are constantly changing. We are sad to say goodbye to two long-standing faculty supporters of *The Synapse*: advisor and neuroscience professor Jan Thornton and Director of Oberlin's Center for Learning, Education, and Research (CLEAR) Marcelo Vinces. We are grateful for all of the support that both of these educators have provided us throughout the past years, and wish them all the best as they move on to other pursuits. If you would like to read more about CLEAR, take a peek at Tara's article *Oberlin's CLEAR Center*, and learn more about its director Marcelo in Victoria's interview.

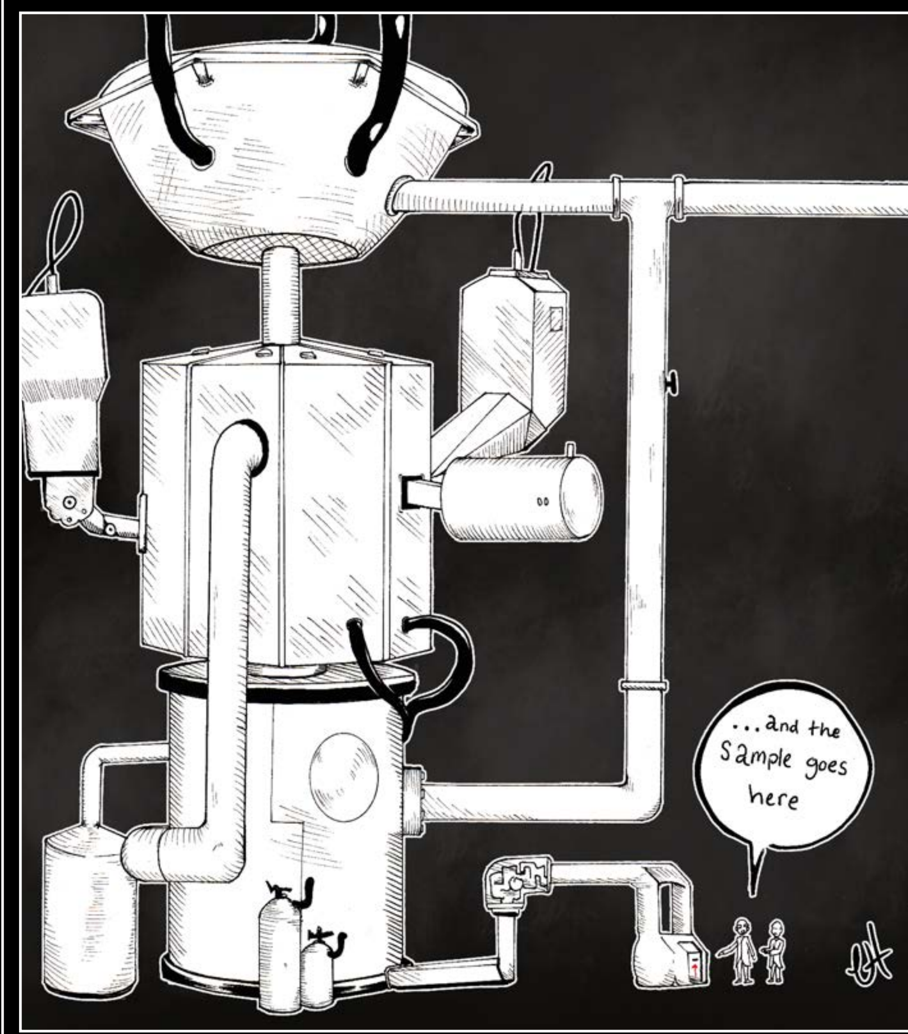
On the other hand, we are thrilled to welcome several new administrative board members to our team. We are excited to announce that, after training during the spring semester, joining our team will be Leah Treidler and Rachael Branscomb as Editors-in-Chief, Sulan Wu as Art Coordinator, and Yue Yu as Chief Layout Editor. We are looking forward to spending a great spring semester passing on *The Synapse's* legacy, and we hope that you are interested in becoming a part of it. Consider applying to work with us! We are excited to explore the unique talents you can bring to the magazine.

Victoria Albacete & Tara Santora
Editors-in-Chief

Contents

Hailing from San Francisco, CA, Jack Bens is a second-year Computer Science and Physics double major. He's illustrated several articles in recent issues of *The Synapse*; you can find his art in this issue with Time for an Upgrade: The Shift to 3D-Printed Casts! Jack believes that science should "always be present in public forums for learning and discussion" and that *The Synapse* does an excellent job of fulfilling that purpose. Post-Oberlin, he tentatively plans to attend graduate school, and in his limited free time, Jack is a game developer and plays Dungeons and Dragons.

Yue Yu is a second-year Biology major from Shanghai, China. She has been a layout editor for *The Synapse* since spring 2017, including for this issue. Yue enjoys working for *The Synapse* because she loves seeing students from different majors and major divisions come together to share their interests and talents. Outside of *The Synapse*, Yue plays flute in the college chamber orchestra and enjoys drawing digitally and scuba diving. Yue first became interested in science, and biology in particular, when she learned that her hair turned from black to brown after shaving it for the first time as a baby, just as her mom's did. In this issue, Yue designed the layout for Nature vs Nurture.



Illustrated by Elena Hartley

Think One Person Can Change the World?

Plants Already Have

Written by Anah Soble
Illustrated by Zimeng Xiang

If the natural history of planet Earth were represented as a 24-hour clock, humans have existed for less than 2 minutes. I think we can pretty much agree that, in those two minutes, we have changed our environment to the extent that the world is unrecognizable. We have created cities and infrastructure, our population has boomed, and greenhouse gasses that we have released into the atmosphere has lead to changes in our climate. Does that make us special? Have we really changed this planet more than anything else? Those looking through all of natural history likely agree that, while we humans have brought all sorts of destruction upon the environment in our short time here, we are far from the only organisms that have revolutionized the makeup of this planet. Plants have been taking over and rewriting the story of Earth for hundreds of millions of years.

Photosynthesis is a way for certain organisms to make food by using light energy to power a series of reactions for producing glucose from carbon dioxide. Oxygen is a byproduct of this reaction, which is poisonous to many organisms if they do not have the structures to process it. Around 3.4 billion years ago, one type of bacteria called cyanobacteria became the first to develop the ability to undergo photosynthesis, which led to a mass extinction of organisms that did not have the ability to tolerate oxygen. The atmosphere had more oxygen than it had ever had before, and it would never go back down to its original levels—a permanent change. Photosynthetic organisms would continue to be important to the world's ecosystems—the base of most food chains, harnessing the sun's energy to produce sugars that other organisms would later rely on for their sustenance. Eventually, a Eukaryotic cell would engulf a cyanobacteria, which, as time goes on, would become what we know today to be a chloroplast. The descendants of these Eukaryotic cells with chloroplasts would develop into multicellular organisms that we now call members of the Plant Kingdom, and the world would never be the same.

Bees, ants, butterflies, and beetles are all pollinators who have, in some way, a reliance on plants due to the way they co-evolved with flowering plants.

Plants would eventually begin to take over. The first land plants, called bryophytes, showed up during the Ordovician period (470 million years ago) and were mosses, liverworts, and other non-vascular plants. The bryophytes didn't have stems or leaves, but they were the organisms that attracted arthropods onto land, leading to the first initial population of land by animals. This would shape life on Earth from this point on. Because arthropods—the group that contains insects, arachnids, trilobites, and other familiar creepy crawlies—have hard exoskeleton-covered bodies, they were pre-adapted to the structural support needed for life on land and therefore were able to quickly populate and diversify. This would eventually attract amphibians, the first land vertebrates, onto land, causing rapid increases in diversity due to the new habitats, new foods, and new evolutionary pressures.

Plants are often the first to colonize new environments. This is also shown in the modern day through the process of succession—in a damaged ecosystem, the first organisms to repopulate are the plants, which are followed by other organisms. Because plants are producers, they drive the ecological direction of a new habitat, which explains their position as a requirement for ecosystem development.

The mid-Silurian, 420 million years ago, saw the first vascular plants, which are plants that have roots and stems. Plants had to adapt to the river environments around them, but they changed the river environments as well. Before vascular plants, streams tended to have a braided structure without the winding and wandering in structured channels that we see in most major rivers today. Once vascular plants began to populate land, the roots bound the sediment, slowing the movement of the fluid and changing the shapes of the rivers. Streams began to form meanders and, once trees began to take over the land, floodplains had complex ecological forms for when rivers periodically overflowed. This information is shown in the sedimentary rocks formed during this period. The shapes of rivers depositing sediment affect the forms in the sedimentary rocks.

Paleobotanists are paleontologists who focus on plant fossils and their surrounding sedimentary rocks to understand how plants shaped the world around them. These specialists have been studying the relationship between plant and river evolution, and have found that they are intertwined. So much of what we currently consider different types of environments have to do with the vegetation that populates these environments. Once trees could populate a floodplain, there were swamps (with giant, meter long dragonflies buzzing around) and, without many decomposers, even higher oxygen content in the atmosphere than there is today (hence the giant dragonflies). Thus, there were comparatively lower levels of carbon dioxide, dropping the global temperature (due to less greenhouse effect) and leading to coal deposits. Today, we are burning coal from these deposits, re-releasing carbon dioxide into the atmosphere and causing an enhanced greenhouse effect, which is leading to an increase in global temperature.

The first angiosperm, or flowering plant, fossils appeared around 125 million years ago during the Cretaceous period. Angiosperms lead to a huge diversification event among pollinating animals through the end of the Cretaceous—yet another example of plants having major effects on their environment. Current living angiosperms are likely most closely related to the earliest angiosperms that were pollinated by insects. This trend continues today; bees, ants, butterflies, and beetles are all pollinators who have, in some way, a reliance on plants due to the way they co-evolved with flowering plants, which either provide a reward such as nectar or edible pollen to the insect, or at least appear to have a reward for the insect, like having flowers that resemble mates. This relationship between plant and pollinator has existed for only a little over 100 million years (just about half an hour on the 24-hour clock), and yet, it is a prominent part of life on Earth today.

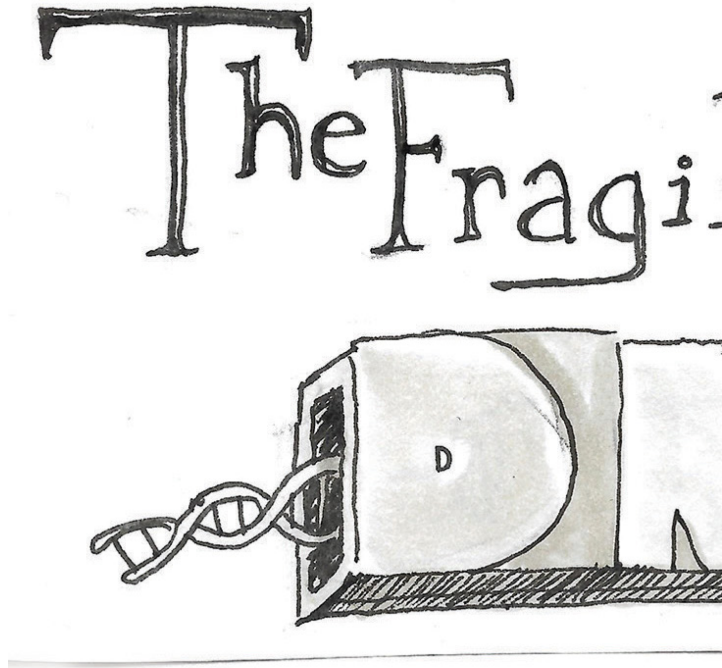
Not only have plants had a profound effect on the history of life, but they are also useful tools for learning more about natural history. Paleobotanists can study plants to key the type of environment an area may have been in the past when the sedimentary rocks do not provide enough information. These scientists do this by looking at the types of organs present. Wide leaves with entire margins (meaning no serrated edges) and drip tips are generally associated with a very wet environment. This is not an infallible method for learning about a past environment (biology is full of exceptions), but it can be a helpful way of providing direction in a study.

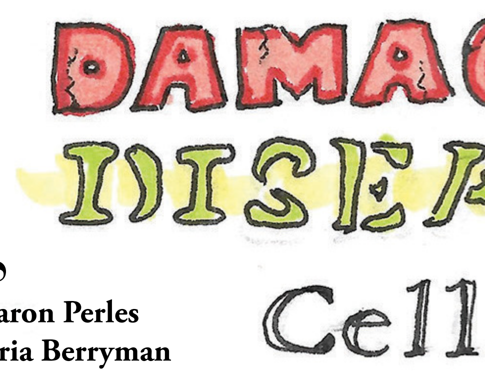
Paleobotanists can study plants to key the type of environment an area may have been when the sedimentary rocks do not provide enough information.

Phytoliths are rigid microscopic structures made from silicates (a type of rock) that were taken up by plants and, in the fossil record, can record all kinds of information, such as the type of plant or the shapes of the plant's cells. Because they are made of silicates, they preserve really well in the fossil record. Phytoliths are affected by light intensity, so they can be used to indicate past light levels in certain locations. The existence of phytoliths in fossilized animal dung (coprolites) also can indicate what certain animals may have eaten while they were alive. Preserved leaf fossils can show bite marks from insects, allowing insect paleontologists to reconstruct insect mouthparts.

Plants have had profound effects on natural history, so much so that they work well as indicators of all different aspects of the environment. Plants get a bad rap among the average introductory biology student because they do not move much in a way that is visible or noticeable to the naked eye, but if we watch over geologic time and are patient, then maybe you can see they're more dynamic than you think.

For more information on this topic, check out Congrad Labandeira's article "The Origin of Herbivory on Land" from *Insect Science*.





Written by Aaron Perles
Illustrated by Aria Berryman

In 2009, the fad of "planking" took the Internet by storm. Images abounded of people lying flat, face-down upon surfaces of all kinds: soft grass, metal statues, escalator railings, and even airport baggage claim carousels. However, those of an especially athletic bent took a challenging approach to the fad, placing themselves on tiny surfaces high above the ground. Think lamp posts, flagpoles, and basketball backboards—structures that support only the abdomen and leave the rest of the body suspended in mid-air, held up solely by the sheer strength of the person doing the planking. To hold this position for even a few minutes requires an incredible amount of core strength. Now, imagine trying to hold this position yourself—for an hour. After five minutes, the vigor has drained out of you, and your muscles have become weak and depleted of oxygen. Unable to hold out any longer, they give out, and you topple from your perch, lying exhausted and broken on the ground.

Now imagine this feat of strength and balance happening at a microscopic scale. Imagine something akin to "planking" inside your cells, where some biomolecule extends itself without support almost beyond its limits. In truth, this kind of phenomenon is a fairly regular occurrence in the DNA double helix. Your DNA experiences small amounts of instability every single day when it replicates itself: the two strands of the double helix unwind, and, for a brief moment, they exist as single, unsupported strands of genetic material. Only once the cell synthesizes two new double helices from the separated strands does the DNA return to its normal, stable state.

As is all too common, however, malfunctions in this biological machine arise. Impediments to DNA replication exacerbate the instability normally resolved during replication. The DNA double helix is shaped like a ladder: two long strands of sugars and phosphates make up the frame of the ladder, while paired nitrogen groups, called *bases*, make up the "rungs" that connect the frame. It is the nitrogenous bases that encode the proteins that comprise every single facet of your body. However, the nitrogenous bases sometimes get damaged. Mutations replace correct bases with incorrect ones, and damaging agents like oxidative stress or ultraviolet radiation cause bases to become chemically corrupted and non-functional. Because the cell is instructed to not replicate corrupt or mutated bases, the double helix stops unwinding at the site of damage while the damage is repaired. The cell has a highly effective mechanism for DNA damage repair, called the nucleotide-excision repair pathway. First, a series of proteins, including RPA and γH2AX, are recruited to stabilize the suspended single-stranded DNA. Then the cell cuts the corrupted base out of the helix and replaces it with a functional nitrogen group so that the unwinding and replication of the DNA can continue as normal.

This mechanism maintains seamless, non-erroneous DNA replication in the cells, but what happens when something goes wrong in the nucleotide-excision repair pathway? What happens when the repair proteins don't come to stabilize the single-stranded DNA while it waits for the corrupted base to be excised? Well, what happens is the molecular equivalent of planking on top of a flagpole. Without the necessary repair proteins, the single-stranded DNA is left alone, unstable without its complementary strand, and completely lacking the support of the repair proteins to hold it steady. Call to mind again the person planking on the flagpole, about to collapse after expending all of their stamina. Imagine that two more flagpoles had sprouted up out of the ground, supporting the person's legs and torso; with this kind of support spanning the length of the body, the person is no longer burdened with the need for excessive core strength to hold themself up. This is the role the repair proteins play for the single-stranded DNA. But, because flagpoles do not magically materialize out of nowhere, the person will inevitably collapse. Without the support of the repair proteins, the DNA gives way under the weight of its own instability, and the entire helix splits in two at the site of damage.

This phenomenon is called a *double-stranded break*, and for the cell that experiences such a break, there can be dire consequences. Because a double-stranded break cleaves an entire segment of the DNA from the replicating double-helix, the cell can lose a staggering amount

of genetic information. Many of these losses can be fairly benign, as significant sections of the human genome are non-coding. But when the double-stranded break occurs in a crucial area of the genome, the results are devastating. For example, cleaving a tumor-suppressor gene increases one's risk of developing cancer. A remarkable amount of research has been conducted on the DNA damage repair genes *BRCA1* and *BRCA2*,

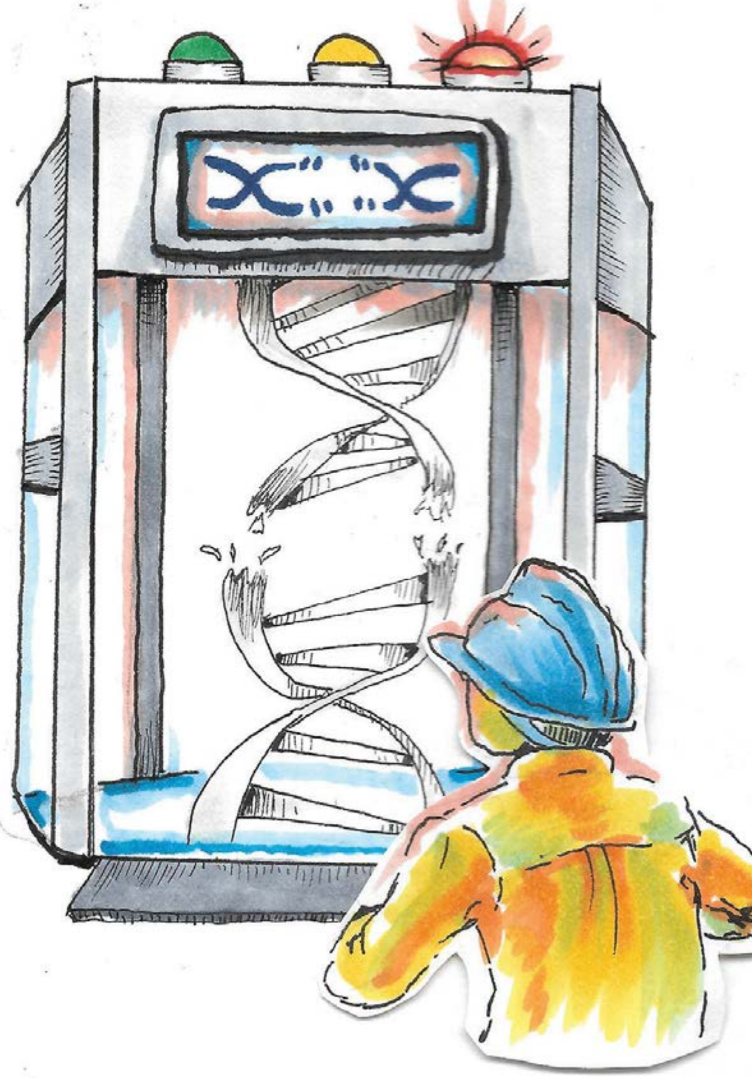
> If a person's cells lack the machinery necessary to repair DNA damage, then double-stranded breaks, and all the consequences that come with them, may be inevitable.

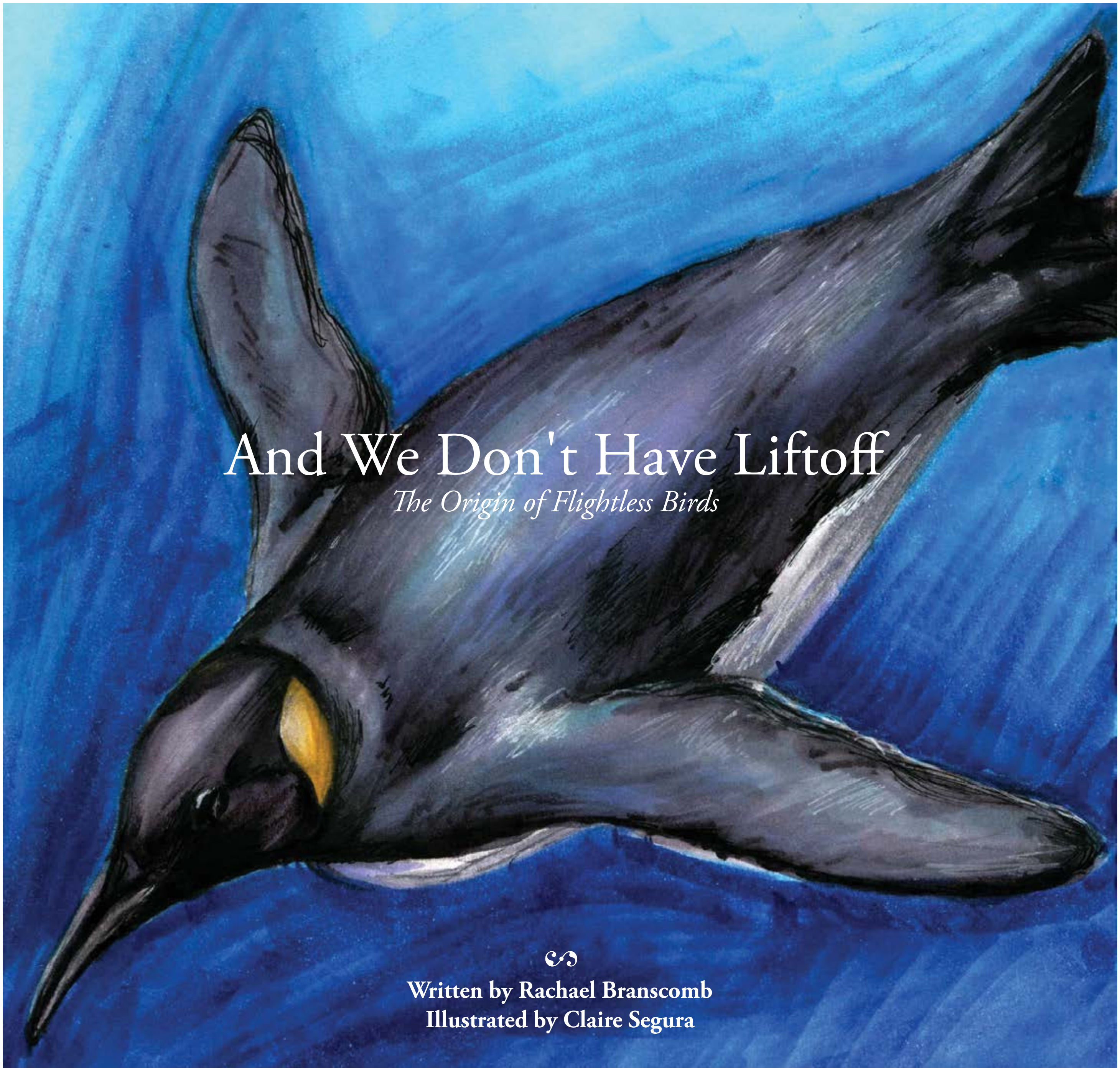
mutations in which have been shown to be significant risk factors for hereditary breast cancer. Another disease associated with faulty DNA damage repair is Werner's Syndrome, in which double-stranded breaks cause impeded growth and premature aging.

If a person's cells lack the machinery necessary to repair DNA damage, then double-stranded breaks, and all the consequences that come with them, may be inevitable. But with this grey cloud comes a surprising, and somewhat ironic, silver lining: the very same cellular predisposition towards double-stranded breaks is also the key to curing the diseases they cause. If one's cells have a heightened proclivity towards losing genetic information, then we can manipulate the corrupt damage repair process, exacerbate the amount of genetic loss, and eventually kill the diseased cells. This has become the primary method of developing chemotherapeutics for diseases associated with faulty DNA damage repair, with the first major breakthrough occurring in 2005. Researchers at the University of Nebraska Medical Center found that inhibiting the enzyme PARP, a key protein in the damage repair pathway, increased cells' sensitivity to DNA damage. Genetic information was lost in droves through double-stranded breaks, and, no longer genetically viable, the cells initiated their pre-programmed death response called apoptosis. On the other hand, we can also deliberately induce cells to proceed with DNA replication despite the helix's damaged or mutated bases, stripping the cell of its time to facilitate a proper damage repair and causing a buildup of enough genetic damage to trigger apoptosis. In the face of deleterious biological mishaps, one of our best strategies is to use the cell's own weapons against itself.

It is rather incredible that so much of our health hinges upon these tiny clusters of sugars, phosphates, and nitrogen. It is rather inconceivable that one small malfunction in these molecules can send our bodies spiraling into harrowing disease. It is rather astounding that this unspeakably essential helix can weaken and shatter, undetectable to our immediate senses. Despite all of this, however, it is also rather wonderful that the same damaged helix, if prodded enough, can become its own worst enemy, destroy itself, and relieve its host of all the ails it had caused—for such a fragile helix it is. ●

For more information, check out "Targeting DNA double-strand break signaling and repair" from *Swiss Medical Weekly* in 2013.





And We Don't Have Liftoff

The Origin of Flightless Birds

Written by Rachael Branscomb
Illustrated by Claire Segura

From the sleek, streamlined penguin gliding through the Antarctic water to the gawky, long-legged ostrich sprinting across the savanna, flightless bird species come in a variety of shapes, sizes, and colors. However, it seems counterintuitive that some bird species have lost the ability to fly, arguably one of the most characteristic avian attributes. Indeed, discrepancies regarding the evolutionary origins of these grounded birds have been consistently ruffling feathers in the scientific community. There are more than 50 flightless bird species in the world, but there is still heavy debate about how, why, and when they lost their ability to fly. Research on this topic has been difficult in the past, as scientists have been unable to analyze the tiny traces of genetic material that are present in extinct bird fossils—a key step in reconstructing the phylogeny of flightless birds. However, technological advances and new research have uncovered genetic information that sheds light on previous theories of flightless bird evolution.

There are multiple groups of flightless birds, including ratites, penguins, grebes, rails, ducks, and even a particular species of parrot. The ratites are the oldest living group of flightless birds, composed of five farflung families that include the ostrich (Africa), the emu (Australia), the cassowary (New Guinea and Australia), the rhea (South America), and the kiwi (New Zealand). Unlike their flying counterparts, ratites cannot fly because they have flat sternums that lack the keel, a bony extension that anchors the pectoral muscles required for flight. Like the ratites, the keels of several other flightless birds also seem to be variably missing or altered, possibly indicating a sustained and gradual loss of flight continuing to this day. For instance, the kakapo, a flightless parrot endemic to New Zealand, has a sternum that has evolved into a depressed ridge. Another feature among all extant ratites is the strange arrangement of the bones in the roofs of their mouths, which seem more reptilian than avian. Though common across ratites, this strange bone arrangement has yet to be explained.

As compensation for their flightlessness, these birds have evolved other mechanisms that help them to survive, such as: stronger bones for running, colorful plumage for camouflage, and webbed feet for swimming. Many ratites are also missing the opposable first toe that flying birds retain, as they have no need to perch on branches.

> Discrepancies regarding the evolutionary origins of these grounded birds have been consistently ruffling feathers in the scientific community.

Their wings, though still present, are typically smaller and shorter, the feathers generally symmetrical and more abundant. Their wings have also developed different non-flying functions; penguin flippers help with swimming and ostrich wings are used as rudders in the air to make agile maneuvers, such as zig-zags, at high speeds.

A theory proposed by Dr. Joel Cracraft in the 1970s speculates that the ratites were scattered around the world as a result of continental drift. He postulated that the ancestral ratites had been living on Gondwana, the southern section of the supercontinent Pangaea, some 200 million years ago, but became scattered throughout the world as Gondwana broke off and drifted from the supercontinent. In support of his suppositions, he linked the order in which continents split from Gondwana to the order in which ratite lineages split from other ratites. For example, he linked the fact that Africa was the first continent to split from Gondwana to the fact that Africa's ratite, the ostrich, was the first ratite lineage to split from the other ratites.

This explanation was generally accepted until the 90s, during which time technological advancements allowed scientists to begin to use DNA analysis to evaluate Cracraft's hypothesis. In 2008, Oliver Haddrath and Allan Baker of the Royal Ontario Museum compared the DNA of the moa, a subgroup of flightless ratites, to that of other ratites and found that the most closely related group to the moa is the tinamou, a family of flying birds present in Central America, Mexico, and South America. The researchers concluded that the tinamous evolved within the ratites and that all ratites originally had an ancestor that could fly. However, the tinamous retained the ability to fly whereas the other ratite lineages independently evolved to lose flight. This challenges Dr. Cracraft's theory that ratites evolved due to the split of Gondwana 200 million years ago, since Cooper and Baker's findings place ratites diverging around 90 to 70 million years ago, with the tinamous and moas diverging about 30 million years later. It is highly unlikely that the tinamou had already lost its ability to fly, was separated by the splitting of Gondwana, and then later re-evolved the capacity for flight.

Even more recently, due to further technological advancements, Dr. Alan Cooper and his colleagues at the University of Adelaide were able to retrieve genetic material from the long-extinct elephant bird. Surprisingly, he found that the closest living relative of the gargantuan 10-foot-tall elephant bird is the kiwi, which stands at only 1.5 feet. Using the genetic material from the two species, Dr. Cooper and his fellow scientists were also able to estimate that the two species shared a common ancestor some 50 million years ago by counting the number of accumulated mutations. This finding puts another serious kink in Dr. Cracraft's hypothesis that the ratites have been flightless since the days of Gondwana. Cooper's findings place the common ancestor living about 150 million years after the separation of Gondwana, which would simply not make sense if the two species had already become isolated on different continents from one another.

Thus, a new hypothesis that attempts to explain ratite evolution in light of these recent findings has been posed by Dr. Cooper and his colleagues; it states that there was a single partridge-like ancestor that colonized much of the world 65-50 million years ago, after the splitting of Gondwana. This resulted in this flying ancestor species evolving the loss of flight independently on each continent. This common ancestor to the ratites would have likely been able to flourish in the new areas because the large plant-eating dinosaurs, that may have been competition for food or resources, had already become extinct, and it would be many millions of years until other large herbivores took their place as competitors. Though seemingly reasonable, there is still much contention over this hypothesis and many scientists, including Dr. Cracraft, do not believe there is sufficient evidence to support this claim.

Currently, there is a general consensus among scientists that flightless birds descended from a common ancestor that could fly, but it is not clear why some birds have lost this ability. One hypothesis is that the ancient flying ancestor colonized isolated areas that did not host any of their natural predators, so flying became much less critical in terms of predator evasion and overall survival. Over time, natural selection may have caused the ability to fly to be lost from the population, eliminating not only the need for flight but also the need to replace flight feathers, conserving energy that might be used to do both. The reduced need for flight appears to be heavily reliant upon environment; flying seems to be much less critical for survival in flightless birds' newer contexts. Flightless birds generally inhabit areas that are predator-free and warm, eliminating much of the need for escape and migration, and they feed off of fruit or fish, which they are able to obtain without flying. The absolute poster child for a region that does not require flight for survival is New Zealand, which has the largest concentration of flightless bird species, due mainly to the lack of large land predators in the region and the warmer climate. Though these birds may have benefited from their lack of flight historically, there are many contemporary threats to flightless bird populations. Currently, more than 50% of flightless bird species are considered threatened and another 20% are considered endangered. Invasive predators such as cats are able to more easily stalk flightless birds and access their ground-level nests. Humans also pose a great threat: flightless birds are generally more susceptible to poaching, litter, pollution, and habitat loss than their flying counterparts because they are unable to take off and relocate easily in the face of bad conditions.

Though the full evolutionary history of today's flightless birds remains unknown, current technology allow scientists to extract DNA from both extinct and living birds. Hopefully, with greater ability to evaluate the genetic similarities between these birds, we will be able to better understand their phylogenetic relationships and the complex evolution of flight as seen among these species. Perhaps we will soon be able to trace the evolutionary tree and find the link between such seemingly disparate species as the penguin and ostrich.

Nature vs Nurture

The Impact of Genes And Environment on Behavior

Written by Ashley Xu
Illustrated by Maria Altier

Nature or nurture? Are we shaped more by our genetics or by our environment? This is one of the fundamental questions of psychology. How do we study a question like this? How can scientists determine what behaviors are the product of one's social environment or upbringing and what behaviors are due to genetics? The answer is twin studies.

Twin studies, especially studies on identical twins separated at birth, are a great way to study the question of nature versus nurture. Since identical twins have the same genetic makeup, scientists can attribute any differences in the twins to the different environments in which the twins were raised in. So, are we influenced more by nature or nurture? To answer this question, let's take a dive into the history of twin studies by investigating what they show about the basis of human behavior and how they advance the study of diseases and disorders.

Jim Lewis and Jim Springer are identical twins who were separated at 3 weeks old and reunited at age 39 in 1979. After talking, they found out that they both were named James by their parents, had a dog named Toy growing up, suffered from headaches, liked math and carpentry in school, drove a Chevrolet, and vacationed on the same beach in Florida. Jim and Jim both grew up in Ohio, a mere 45 miles apart from each other. Additionally, both twins had married a woman named Linda, then divorced Linda to marry a woman named Betty. Jim Lewis named his child James Alan Lewis, and Jim Springer named his child James Allan Springer. News of the Jim twins got to the University of Minnesota, and Thomas Bouchard Jr., a psychologist at the university, was intrigued by the Jim twins and invited them into his lab for testing.

Bouchard's team of researchers at the University of Minnesota was conducting a longitudinal study, which measures changes over a long span of time. The goal of the research was to find as many pairs of identical twins as possible in order to compare the personality differences between the twins. Over the span of 20 years, from 1979 to 1999, The Minnesota Twin Family Study followed the lives of 137 pairs of twins. Participants in the Minnesota Twin Study were evaluated on traits such as personality, interests, family/social relationships, religion, health, physiological measurements, academic ability, mental health, and criminal record. 81 pairs of the twins were monozygotic or identical twins, meaning that the twins developed from the same egg in the womb, and 56 pairs of the twins were dizygotic or fraternal twins, meaning the twins developed from two different eggs. These twins were all reared apart, meaning that the twins were separated at a young age (typically only weeks old) and raised in separate households by separate families, with no interaction with one another. The main finding of the Minnesota Twin Study was that identical twins who were raised apart had striking similarities in personalities, interests, and attitudes. So, the Jim twins are not an exception to the rule, even if they are an extreme example.

Researchers specifically targeted studying identical twins because identical twins share 100% of their genetic material, which allows researchers to calculate the heritability of certain traits. Fraternal twins share around 50% of their genetic material, meaning that researchers can also form a general idea of the impact of genes on fraternal twins' behaviors. If identical twins are more similar in a certain trait than fraternal twins are, scientists can attribute genetics to being the main influencing factor in developing that trait. However, if identical and fraternal twins are equally likely to share a trait, then environmental factors are likely more influential in the development of that trait.

Identical twins allow scientists to study the exact degree to which environment affects an individual's development because any difference in the twins can be directly and completely accredited to environmental influences. Through examining all of the twins, Thomas Bouchard and his fellow researchers consistently found that genetic and environmental influences play roughly equivalent roles in terms of importance in the development of human behavior. For example, in twin pairs who have schizophrenia, 50% of identical twins share the disorder, whereas only around 15% of fraternal twins do. The fact that there is quite a high chance of one identical twin developing schizophrenia if the other has it shows that there are genetic influences that may increase susceptibility to schizophrenia, but there are also other factors at play (such as environmental influences) because identical twins do not both develop the disease 100% of the time.

The Minnesota Twin Study was not the first twin study conducted. The origin of twin studies dates back to around 1875, when Francis Galton, one of the first people to investigate human twins and heritability of traits, published his research paper, "The History of Twins." Galton coined the terms "nature and nurture", and his paper was the starting point of today's nature vs. nurture debate. However, it is worth noting that Galton went down a dark path when his research led him to the staunch belief that intelligence was due to nature, which resulted in him advocating for the breeding of humans to create an "improved" human race. He invented the term "eugenics," which is a set of beliefs and practices that aims to selectively breed humans to have the most desirable genetic characteristics.

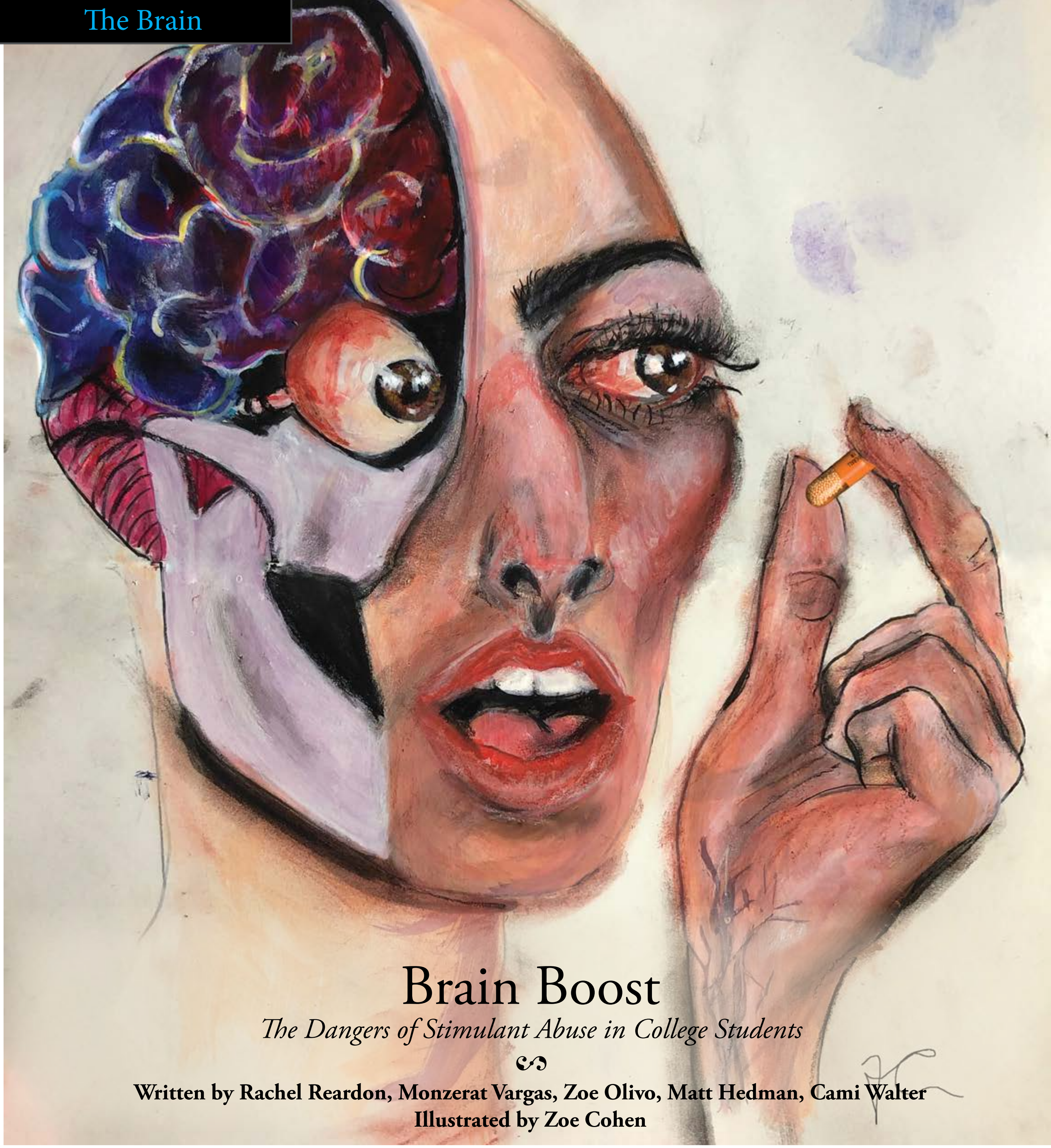
Twin studies have progressed since Galton and have generally left eugenics for a more moral understanding of nature and nurture, such as how genetics and environment affect disease. In 1992, the TwinsUK twin registry was founded by Tim Spector, a professor of genetic epidemiology at King's College in London. Over 600 papers have been published by various researchers using data from the TwinsUK registry showing that common diseases such as cataracts, osteoarthritis, and back pain are influenced by genetics. In 2001, the Michigan State University Twin Registry was founded to study the effects of genetics and environment on medical and psychological disorders. These researchers found that some eating disorders, such as anorexia, have genetic influences rather than solely environmental causes.

A modern-day twin study is that of identical twin astronauts, Scott and Mark Kelly. In March of 2016, Scott Kelly returned to Earth after 340 days on the International Space Station (also known as the ISS, one of NASA's habitable satellites in low orbit around Earth)—the longest time an American has spent in space. During this same span of time, Scott's brother Mark Kelly stayed on Earth. Mark is a retired astronaut who has spent 54 days in space over his career, after four space shuttle missions to the ISS. Since each of these space missions lasted only for a short span of time, the trips did not affect Mark's ability to act as a control subject on Earth to compare to Scott on his almost year-long trip in space. Since Scott Kelly landed on Earth, researchers from NASA and a host of different universities have been running numerous tests on the twins, both physical and psychological, to understand the effects of long-term space travel on the human body. This is the first study to be done on twins in space, and NASA is hopeful that it may be instrumental in one day sending humans to Mars. Although the sample size of only Mark and Scott Kelly is a small one, scientists hope that studying the differences between Mark and Scott can lead not only to creating safer environments for astronauts traveling to space, but also open the door to future twin studies in space.

Twins also give scientists a chance to investigate the field of epigenetics, the study of changes in chromosomes that affect gene expression but do not alter DNA sequences. The epigenome consists of all chemical compounds and proteins that are added to human DNA (the genome) and tells the genome what to do by regulating gene expression. Epigenetics can account for the small physical differences that sometimes can be seen in identical twins, such as one twin being several inches taller than the other. Epigenetics causes these small differences because environmental factors such as physical activity, diet, stress, or exposure to toxins (through behaviors such as smoking) may cause the expression of some genes in one twin, but not in the other. Epigenetics research performed on twins is vital to science because the epigenome may influence the development of certain diseases such as cancer. Further research into the epigenome may lead to discoveries on how to cure or better treat diseases.

> Twins also give scientists a chance to investigate the field of epigenetics, the study of changes in chromosomes that affect gene expression but do not alter DNA sequences.

Scientists have been studying nature and nurture for decades, and at this point, there is a general consensus on this fundamental question of psychology. In recent years, psychologists have realized that asking the question of exactly *how much* of behavior is due to one's genetics and *how much* is due to one's environment may not be the right question to ask because the line between nature and nurture is a blurry one. All human behaviors are affected and influenced by *both* nature *and* nurture, such that scientists cannot say exactly what percentage of a behavior is due to heredity and exactly what percentage is due to one's upbringing. It is impossible to say that any specific behavior is entirely due to genetics or entirely due to the environment. Nature and nurture are undeniably and inextricably intertwined, and the two are in constant interaction to form the complexities of human behavior.



Brain Boost

The Dangers of Stimulant Abuse in College Students

Written by Rachel Reardon, Monzerat Vargas, Zoe Olivo, Matt Hedman, Cami Walter
Illustrated by Zoe Cohen

College students face persistent pressure to maintain high grades and cultivate an active social life. Due to this pressure, some turn to stimulants to facilitate better academic performance. These students often refer to stimulants as study tools. College students often believe stimulants will improve their grades, increase focus, and reduce anxiety. However, of these supposed benefits, stimulants have only been shown to have a positive effect in students who have an ADD or ADHD diagnosis.

Studies indicate that students most at risk of stimulant abuse are white students in fraternities and sororities. Others at risk include students with below average grades and increased levels of stress, anxiety, and depression. Students often receive access to stimulants through peers with ADD/ADHD prescriptions, but this raises a number of potential moral issues. Those with stimulant prescriptions often feel peer pressure to sell their pills to fellow students. The student with ADD/ADHD feels responsible if the stimulant harms fellow students, and the student with ADD/ADHD is also harmed since they are not taking their prescribed medication. Moreover, sharing prescription medicine is a felony.

Ritalin is sometimes referred to as the "smart drug," rhetoric which persuades more students to abuse the drug in hopes of performing better in academics or athletics. However, as good as students might feel in the moment when consuming Ritalin and other stimulants, there can be negative outcomes. Notably, misuse of prescription stimulants can lead to addiction, and consuming too much can lead to overdose and death. Some of the side effects a person can "hide" can include loss of appetite, dizziness, depression, and increased heart rate. Other side effects include seizures, panic, weight loss, and pupil dilation. These side effects could occur when using either Ritalin or Adderall.

Individuals dependent on Ritalin or Adderall rely on the drugs to function normally on a daily basis. Because the brain is accustomed to receiving high doses of the neurotransmitters from the drugs, it slows down endogenous production of those chemicals, therefore making it difficult to wean someone off the stimulant. As the brain is in recovery, an individual might experience a mental crash, described as feelings of depression or numbness.

These types of withdrawal effects can be explained by the action mechanism of stimulant drugs. The key neurological feature seen in patients with ADD/ADHD is the disruption of serotonin neurotransmission. Adderall and Ritalin, two of the more common prescription stimulants, therefore have the key function of increasing serotonin activity in the brain. Both of these stimulants can be short-acting but have different mechanisms of action within the brain. Ritalin acts as a serotonin and dopamine reuptake inhibitor, while Adderall causes increased release of dopamine and norepinephrine in addition to decreasing serotonin reuptake.

Serotonin is widely believed to contribute to happiness, regular sleep patterns, and building memory and learning pathways while dopamine is the neurotransmitter most commonly associated with reward pathways in the brain. A review article published in *Brain and Behavior* suggests that while attention deficit has long been the defining feature of ADD/ADHD, issues in the reward and motivation pathways of the brain may be just as important in clinical development of the condition. Recent studies in humans have shown that taking Ritalin significantly increases dopamine activity in the ventral striatum, a region of the brain strongly linked to motivation and rewards.

While the details about exactly how Adderall and Ritalin work to alleviate the symptoms of ADD/ADHD are unknown, several inferences can be made based on their respective neurological functions. Since serotonin is implicated in learning and memory, increasing its activity in the brain may help improve a person's ability to carry out learning and memory tasks. Additionally, higher dopamine availability may cause stronger activation in a person's motivation pathways, thus making work seem more salient and helping an individual to focus more effectively on tasks.

However, these stimulants are not magical "smart pills" that result in improved cognition whenever they are used. In fact, multiple studies referenced in *Brain and Behavior* have shown that taking Ritalin or Adderall has no association with long-term improved academic performance. When used by individuals without an ADD/ADHD diagnosis, stimulant drugs have been shown to aid in short-term focus and rote memorization tasks. However, use by these individuals does not correlate with improvements in complex memory or critical thinking. In the long run, stimulant usage by this demographic is thus likely to do more harm than good in terms of academic success. The initial burst of focus might help students "cram" information before a quiz or exam. However, the students will not have effectively encoded the content in a way that will increase success on cumulative papers or exams.

> Notably, misuse of prescription stimulants can lead to addiction, and consuming too much can lead to overdose and death.

Though Adderall can help students with ADD/ADHD, grave consequences accompany its use in conjunction with other drugs, regardless of whether a person has ADD/ADHD or not. Adderall, being a stimulant, speeds up the activity of the central nervous system. Alcohol, being a depressant, reduces the activity of the central nervous system. Many people are mistakenly under the impression that the two drugs will cancel each other out, but rather they work against each other. Mixing Adderall and alcohol is considered to be one of the most dangerous combinations of intoxicants but is unfortunately one of the most common.

The combination of these two substances causes the perception that both the alcohol and the stimulant are not as intense, even though the actual content of each drug has not been altered. Adderall can dull or even mask the symptoms of being drunk, often making it more challenging to realize how much alcohol one has consumed; however, the opposite effect can occur as alcohol blunts the perception of the stimulant effects. In this situation, risk of overdose on either substance is high. In addition, this dangerous combination leads to a significant cardiovascular stress and impairs judgement and rational thinking. One could experience increased blood pressure, rapid or irregular heart rate, and the urge to partake in aggressive or risky behavior.

Stimulant abuse also has legal and social implications. Adderall and Ritalin are classified as a Schedule II controlled drugs by the federal government, the same class as cocaine and methamphetamines. Illegal possession can result in harsh penalties such as fines and possible jail time. Additionally, if someone is caught selling these drugs, the penalties are even more severe. Fines range from $5,000 to $10,000 and individuals could be sent to jail for up to 10 years.

Stimulant use is becoming more socially acceptable among college students. Students view Ritalin and Adderall as study tools to help them focus. However, these drugs can have long-lasting effects such as physical dependence, weight loss, and migraine headaches that affect both the individual and their relationships. Overall, while Adderall and Ritalin have important clinical applications in the treatment of ADD/ADHD, they do present risks for numerous physiological and social consequences. College students need to be aware of these risks in order to approach these substances with the appropriate caution.

Bog Bodies

Tracing Human Narratives Through Interdisciplinary Methodology

Written by Ally Fulton
Illustrated by Roger Ort

It came seemingly out of nowhere, the massive rogue bog that inched across North Long Lake in Brainerd, Minnesota. Home to a sizable tamarack stand, the thousand-ton bog broke free from the shoreline and wandered around the lake, crashing into a dock and a boat. Locals were astounded by its swiftness, as it traveled over 2 miles in just a few days, circumnavigating the lake.

Bogs have captivated the human imagination for more than such strange wanderings. Found across the world, bogs inhabit a marginal space that is neither completely saturated, nor wholly solid land. In fact, they are characterized by layers of acidic water, spongy peat (partially decayed organic material), and sphagnum moss. They get most of their water from precipitation, rather than from groundwater or runoff. Consequently, they have very few of the nutrients necessary for plant growth. These acidic, low-oxygenated landscapes are formed in two ways: terrestrialization and paludification. Terrestrialization occurs when the sphagnum moss slowly grows over a lake or pond and begins to fill it, whereas paludification happens when sphagnum moss starts to cover dry land and prevents water from escaping the surface. In both instances, as the moss continues to grow, the acidic peat deposits begin to build up over thousands of years.

The aura of instability around the bog has personified it as both peculiar and spiritual, and even as evil or malignant. It is within this uncanny ecosystem that emerges perhaps the most revered image of the bog—the bog body. A bog body is a preserved human cadaver that has been mummified in the anaerobic, highly-acidic, low-temperature bog environment. These preserved human specimens date back to 8000 BCE (e.g. the skeleton of the Koeljberg Man from Denmark) and up to World War II (e.g. entirely preserved Russian fighter pilots killed in the wetlands), though most are dated to the Iron Age (500 BCE–100 CE) in Northern Europe.

Throughout history, particularly in the Iron Age, bogs were considered sacred places of worship, and bodies were thrown into bogs for punishment or ritualistic purposes. At this time, northern Europe was shrouded in dense forest canopies. In comparison, the bog was a relatively wide-open and murky landscape, a mystical borderland. Thus, scholars think that bodies entombed in bogs are sacrificial objects. The main form of interpreting the history of the bog bodies, and the communities the bodies lived in, is the striking physical record of the bodies themselves. Most of the corpses do not seem to have reached their end by natural causes—for many, theirs was a gruesome death by stabbing, hanging, or other violent means.

Intimate physical details are retained because a body in a bog decays very slowly. Once deposited into a bog, acid begins to tan the body, giving it a leathery appearance. Over time, sphagnum moss dies and frees sphagnan, a carbohydrate polymer. Sphagnan extracts calcium from the body's bones and breaks them down, which makes the corpse looks deflated. However, the sphagnan binds with nitrogen, which stops bacterial growth and preserves the corpse's bodily attributes, down to fingerprints, nails, facial features, and internal organs. The detailed preservation of the bodies lends them incredibly lifelike auras. *The Smithsonian Magazine's* Joshua Levin describes viewing one bog body, the Tollund Man, found in Silkeborg Denmark's Bjaeldskovdal bog: "What really gets you is his lovely face with its closed eyes and lightly stubbled chin. It is disconcertingly peaceful...You'd swear he's smiling, as if he's been dreaming sweetly for all those centuries."

Because of the exceptionally lifelike nature that Levinson describes, bog bodies stir the literary and historical imagination, giving us physical, seemingly immediate unfettered insight into lives of people from thousands of years ago. We persistently ask questions about the bog bodies even as our scientific methods paint clearer pictures of who the bog bodies were when they were alive. Bog bodies grip our imaginations and submerge our minds in the muddy, turbid waters of the bog. "They are so alarmingly normal, these bog folk," Levinson writes. In effect, the bog bodies make us identify with them in a way that other mummified corpses are unable to do.

Karin Sanders, Professor of Danish Literature at the University of California, Berkeley, provides a frame for understanding this incessant curiosity with bog bodies in her book *Bodies in the Bog*. "I suggest...that we see bog bodies as unique go-betweens on many fronts, straddling not only the binaries of time and space, past and present, text and image, and ethics and aesthetics, but also the disciplinary boundaries between archaeology, history, literary studies, and art history." In this way, the bog bodies ask for an interdisciplinary methodology that uses literary reading and method-driven archaeological and historical examinations to raise questions about the existence of the many binaries Sanders presents.

> Bog bodies grip our imaginations and submerge our minds in the muddy, turbid waters of the bog.

Additionally, Sanders addresses how bog bodies occupy the same fluctuating temporal and physical space as the bog environment that is in constant movement and growth. The bog body is both seen as archaeological material and a human being. When the body is seemingly born again out of the layers of peat as a scientifically preserved specimen that will sit in a museum, a tension arises between this establishment of the bog body as an inanimate object, yet also a human being. Thus, the bodies are, as Sanders elucidates, "estranged from us even as they mirror us."

Moreover, in the process of being unearthed, the bog body regains personal pronouns. However, almost all bog bodies are still assigned place names, such as the Tollund Man, Graubaulle Man, or Lindow Man, all named after villages near where the bodies were found. Bog bodies persistently occupy a middle ground where they are both human and thing. In this gray borderland, the bog body serves as a site for unraveling human narratives.

Gaston Bachelard, a French philosopher, suggests that bogs are an active and creative agent in the material imagination. Likewise, the bog body, as a narrative landscape, offers a space for interdisciplinary imagination and thought. As Anthony Purdy, a Canadian literary scholar, ascertains, the bog body becomes an agent of personal and cultural memory.

Bog bodies offer a way to shake up strict disciplinary thinking. Instead of approaching a matter strictly via scientific or archaeological methodology, bog bodies and the bog landscapes they come from force us to release our tight intellectual grip on the paradigms and dogmas we have come to accept as truth. In their refusal to be strictly defined or imagined, the bodies give us a way to think differently, ask new questions, and delve into uncertainty. ●

If you're interested in learning more about bog bodies, check out Jeanie Evers' article "Bog" published in *National Geographic*'s September 2012 issue.

Germ T

How We Became Acq

Written by Ca
Illustrated by D

My body aches as I trudge through daily activities. Even placing one foot in front of the next seems laborious. Further, my airways are partially blocked because of mucus accumulating in my sinuses. I contemplate how I took a smooth breath for granted. Most people today would deduce that I have fallen under the influence of the common cold. They would also likely conclude that my cold originated from some strain of bacteria. Although this idea may seem elementary by today's standards, Germ Theory, the belief that diseases arise from microorganisms like bacteria, is a relatively new concept.

For centuries, society widely held an entirely different belief about the origins of disease—one that associated disease with poisonous vapor. The Miasma Theory, a concept asserting that decaying matter in foul-smelling air caused diseases, reigned as the "scientific truth". Believers in the theory stressed preventative approaches such as cleansing to avoid infection. The belief originated in the Middle Ages and endured into the 1900s. The airborne nature of the disease is why physicians during the Bubonic Plague wore the iconic bird-like masks. The masks ostensibly protected the doctors by containing a respirator with dried herbs and flowers in the beak to combat noxious smells. Unfortunately, the masks did not address the actual issue, bacterial infection. As a result, many plague doctors passed away from the disease. Although the plague eventually subsided, the Miasma Theory stood strong. It was not until the late 1840s that it would be substantially challenged.

The first threat to the Miasma Theory came in the wake of the Industrialization Age of London, when pestilence ran rampant through the streets. The rapid industrialization led to unfit living conditions. Urban areas of London were poor, filthy, densely-populated, and foul-smelling neighborhoods, so they tended to be ground zero for epidemics. One such epidemic was the outbreak of Cholera in the SoHo area of London. This disease was characterized by acute diarrheal infection that proved to be fatal within hours. Based on the Miasma Theory, Londoners believed the deadly disease was spread through toxins hovering within the SoHo air.

Physician John Snow held skepticism in the etiology. He noticed that his patients' symptoms were centralized in their digestive tracts instead of their lungs. Snow's doubt in the legitimacy of the Miasma Theory grew into a full investigation of a Cholera outbreak. Snow found that the vast majority of the infected lived around the Broad Street water pump. He hypothesized that the Cholera outbreak was due to a water supply contamination from a nearby sewage pipe. The English physician was beginning to formulate his rejection of the Miasma Theory.

The Miasma Theory, a concept asserting that decaying matter in foul-smelling air caused diseases, reigned as the "scientific truth".

After collecting samples from the water supply, Snow observed the potentially hazardous water under a microscope. He noticed microorganisms swimming in the liquid, proving his contaminated water theory. Snow requested Parliament to shut down the Broad Street water pump to contain the SoHo Cholera epidemic. Although Parliament was slow to respect Snow's request, the watering pump was eventually shut down. Correspondingly, the Cholera outbreak subsided. John Snow's work to prove that the source of the disease was contaminated water stood as the first step toward Germ Theory. Others would follow in Snow's footsteps to invalidate Miasma Theory.

The next important scientist was Louis Pasteur, a French chemist who established himself in the medical world with an array of legacies. Three of his most impactful discoveries involved the beer industry, the silk industry, and the development of the first vaccine. In 1856, Pasteur investigated why

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certain beers were prematurely spoiling. He examined samples and found thousands of microorganisms in the beer to be the cause of the issue. Pasteur concluded that microbes putrefied the beer when he discovered that heating the beer killed them and preserved the drink. This microbicide technique is known as pasteurization, and it is widely used today to preserve drinks like milk, beer, and wine. This discovery heavily influenced several industries and brought forth the notion of microorganisms' effect on beverages. However, it was not until Pasteur's next two discoveries that public health was forever changed.

In 1865, Pasteur was approached by a man from the silk industry seeking help. His silkworms were dying from a disease called pébrin at a rapid rate, and it was slowing his production. Pasteur accepted the challenge

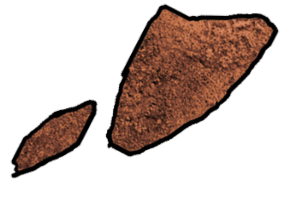
It is hard to believe it was not until the end of the 19th century when Germ Theory became widely accepted, since we take this theory as a given in modern society.

and visited the factory. After several experiments, the chemist concluded that the silkworms were inflicted with multiple diseases that were spreading through the consumption of infected feces. This conclusion proved significant because it showed that diseases could spread through microbes into living organisms. His victories in industry added substantial support to the developing Germ Theory. Pasteur's next discovery would be the final and most convincing point for the young Germ Theory and would change medicine forever.

In light of Edward Jenner's development of the smallpox vaccine, Pasteur hypothesized that there was a different vaccine for every disease. The French chemist utilized Cholera cultures from chickens to test this theory. He cultivated Cholera and found that injecting healthy chickens with the culture would induce the disease. In the summer of 1880, he found a forgotten Cholera broth. When he inoculated the chickens with the old broth he found that the chickens did not die. In fact, he proved that the old broth provided a resistance to subsequent Cholera exposure. This discovery provided a vaccine for Cholera as well as concrete evidence that germs are the root of disease. Germ Theory would be further refined with a third's physician's findings—Robert Koch.

Koch, a German physician, cemented Germ Theory by building on Pasteur's work. The doctor followed Pasteur's rudimentary Germ Theory by proving specific microbes cause specific diseases. Koch extracted a blood sample of a deceased, anthrax-infected sheep. He then cultured the anthrax and injected it into a mouse. He found that infected mice suffered from anthrax too. In 1876, after generations of repetitions of the experiment, Koch concluded that the specific bacteria strain was the cause of anthrax. Robert Koch's discovery propelled the scientific community toward accepting Germ Theory. The physician proved not only that diseases arise from microbes, but also that a specific disease is inflicted by a specific microbe. Koch's work led him to be one of the founders of bacteriology.

The tremendous efforts of John Snow, Louis Pasteur, and Robert Koch drove Germ Theory to where it stands today. John Snow fought against adversity for the public health of his fellow Londoners. Louis Pasteur established that microorganisms bring about diseases. Robert Koch developed a vaccine for anthrax and determined that specific bacteria lead to specific diseases. These discoveries built our understanding of germs today. It is hard to believe it was not until the end of the 19th century when Germ Theory became widely accepted, since we take this theory as a given in modern society. Reflecting on these scientists' arduous path to establish a scientific truth begs a question about modern society: what truths do we blindly disregard today because they simply differ from the current belief?



Helping People Breathe

Cystic Fibrosis and Gene Manipulation

Written by Lameya Aamir
Illustrated by Valentina Zhang

Cystic fibrosis is a genetic disease that affects different parts of the body, primarily the lungs. The symptoms of cystic fibrosis can include persistent lung infections, an inability to breathe, constant coughing, phlegm accumulation, poor growth/weight gain, and bowel movement problems. Patients with cystic fibrosis have an average lifespan of 30 to 40 years. However, due to some recent discoveries, this lifespan might be increased.

One of the reasons why scientists and medical professionals have struggled to address cystic fibrosis is because it is a genetic disease that can't be prevented, unlike bacterial or viral infections. Cystic fibrosis is caused by the presence of two copies of a recessive allele. Therefore, two parents, both of whom carry one allele for the gene, have a 25 percent chance of having offspring who have cystic fibrosis and a 50 percent chance of having offspring who are carriers. That specific recessive allele exists due to a mutation in the gene, and there are more than 1,000 known mutations which result in cystic fibrosis. The resulting effects also vary in the patients due to the different mutations and different genetic makeups of the patients.

Several treatments—such as pancreatic enzyme supplements, inhaled medication, and airway clearance—have helped add many years to the lives of cystic fibrosis patients. Furthermore, investment from different

> Cystic fibrosis is a genetic disease that can't be prevented, unlike bacterial and viral infections.

initiatives is currently being devoted to finding more cures and treatments for the disease, while also furthering understanding of its foundations.

One of the most recent new discoveries about cystic fibrosis considers the genetic makeup of patients who are less severely affected by the disease. Carried out by a team of researchers at the Boston Children's Cystic Fibrosis Clinic, an analysis of the coding sections of the genome—which can contain the most disease-causing mutations—in these patients
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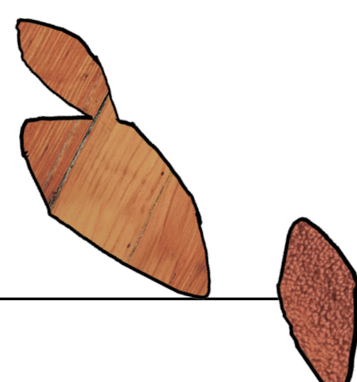

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eam is now doing further research to analyze ients who are affected more severely by the g research proves successful, people with d might be on their way to breathing more

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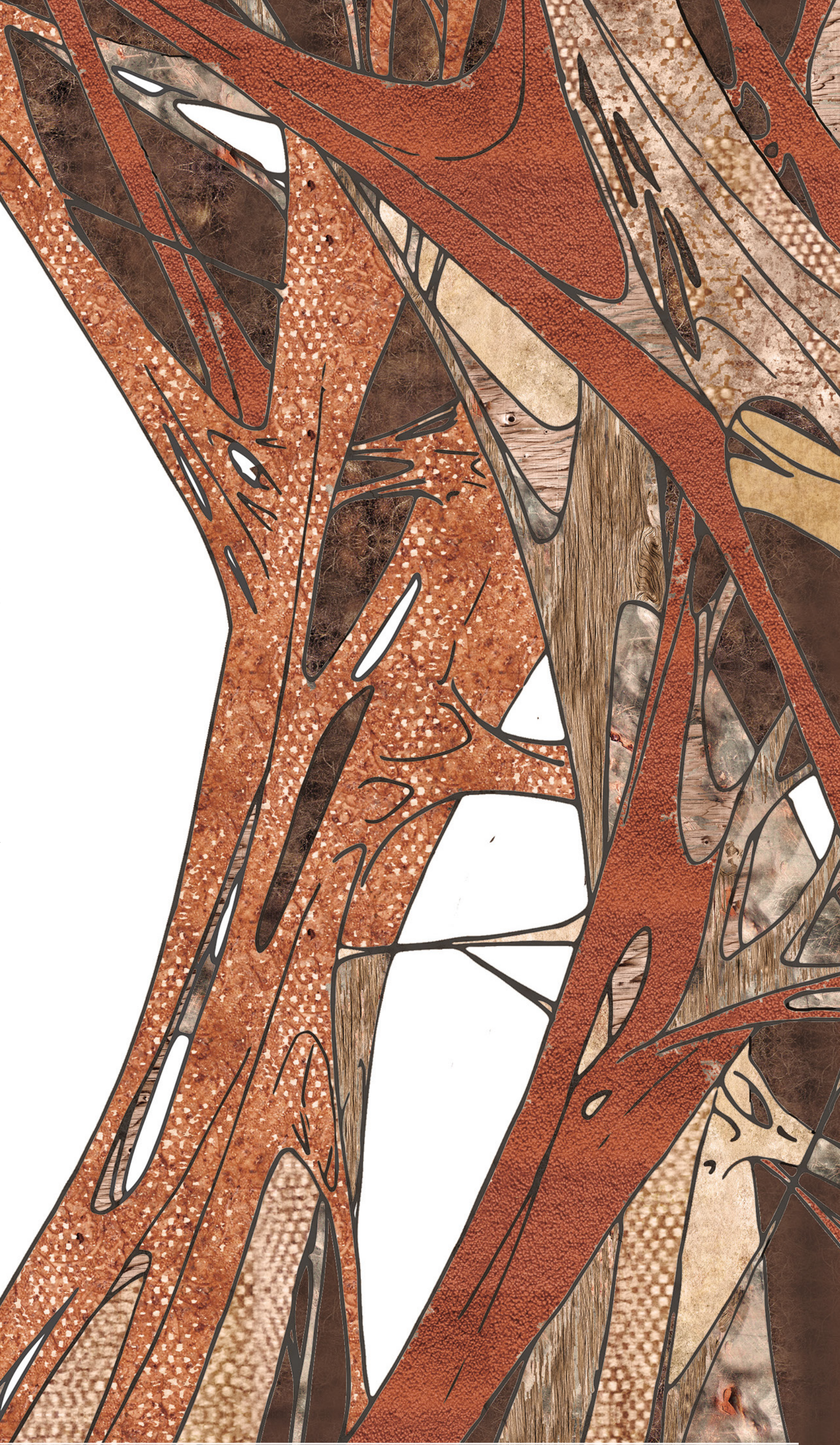
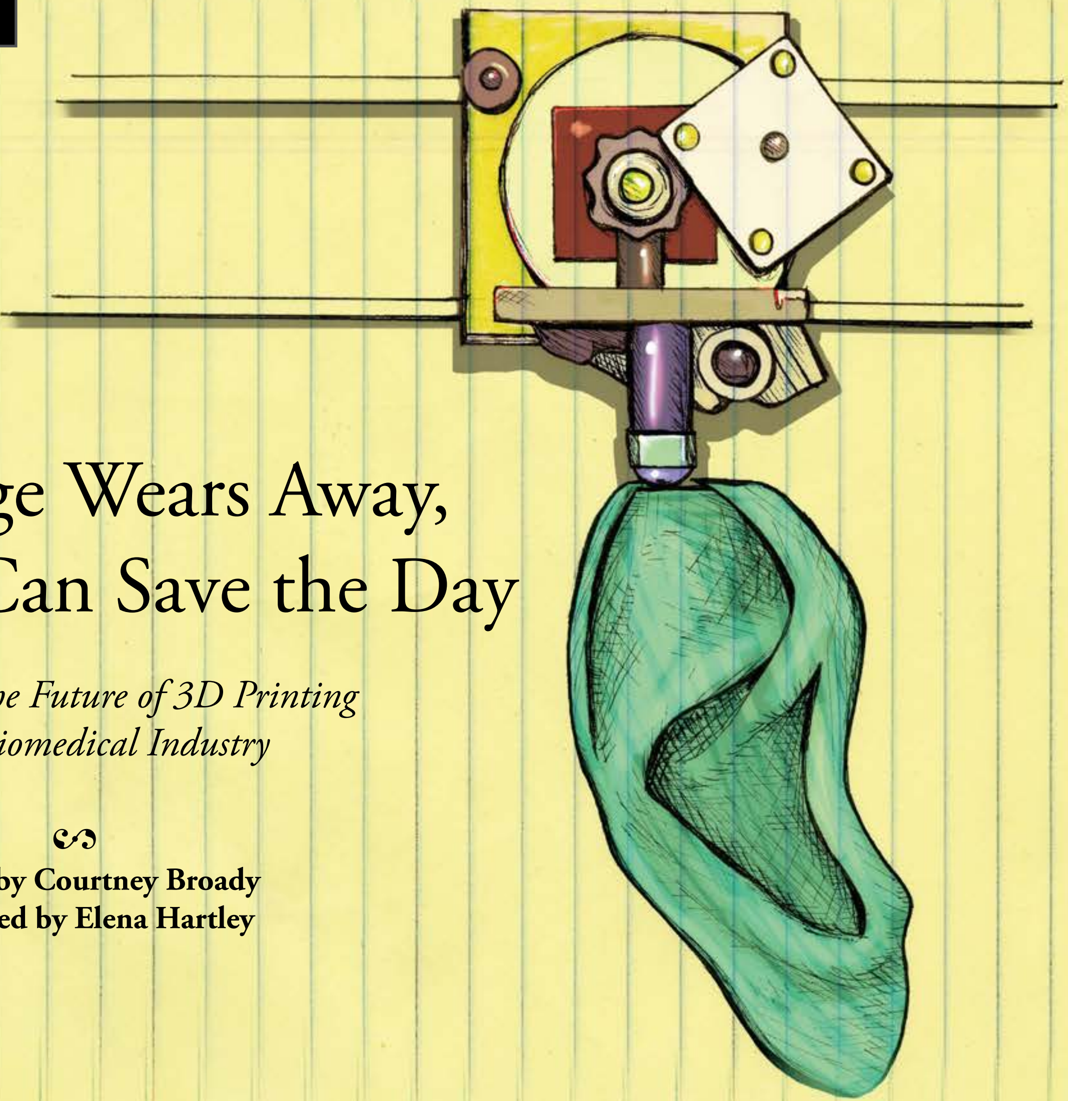




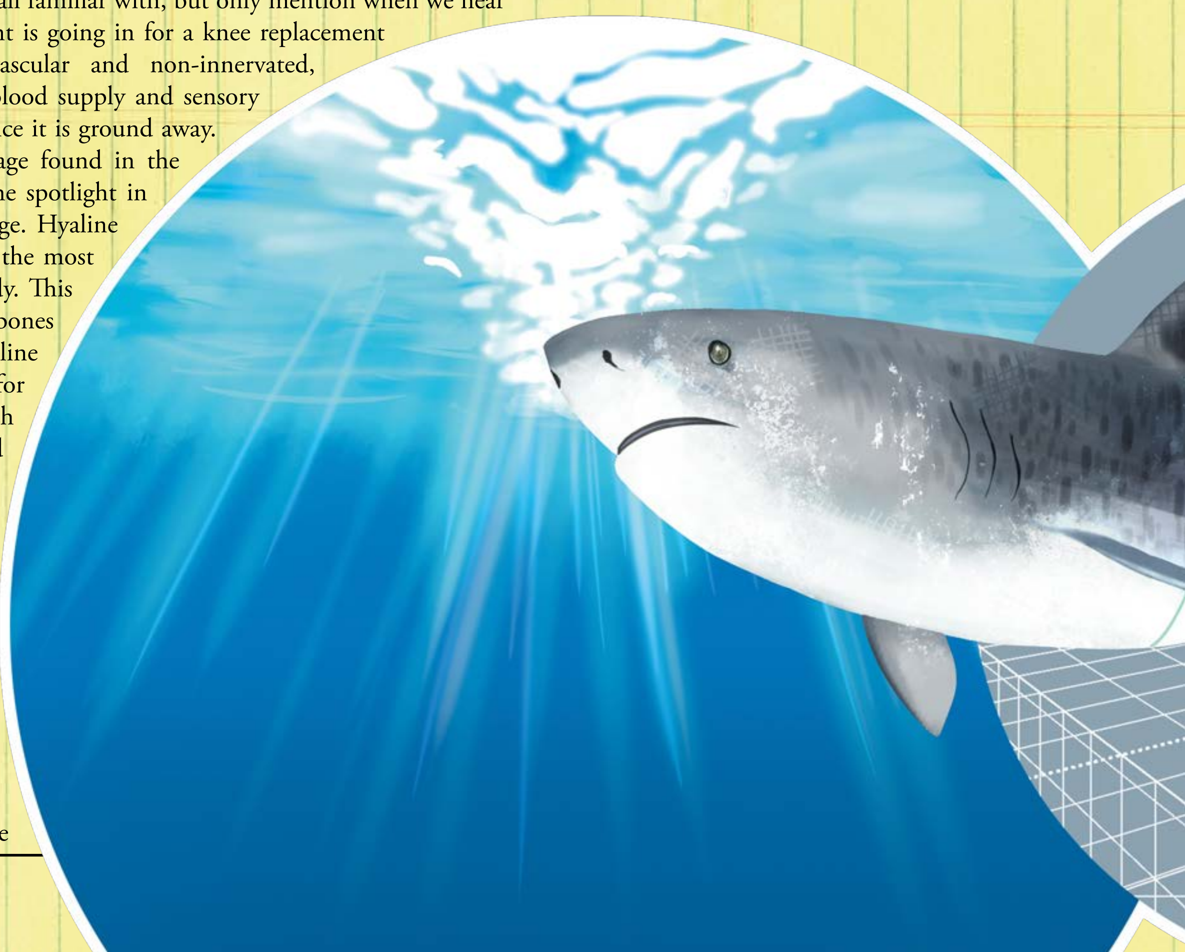
If Cartilage Wears Away, Hydrogels Can Save the Day

A Look into the Future of 3D Printing in the Biomedical Industry

Written by Courtney Broady
Illustrated by Elena Hartley

Cartilage. It's a term we are all familiar with, but only mention when we hear that someone's grandparent is going in for a knee replacement surgery. Cartilage is avascular and non-innervated, meaning that without a blood supply and sensory function, it is unable to regenerate once it is ground away. There are three main types of cartilage found in the human body, but the one that has the spotlight in the biomedical field is hyaline cartilage. Hyaline cartilage is a shiny blue color, and is the most abundant type of cartilage in the body. This cartilage is found at the ends of long bones like the humerus, femur, and ribs. Hyaline cartilage provides a smooth surface for tissues and joints to glide against each other and also provides flexibility and impact support. Recently, biomaterial scientists have been researching ways to create new cartilage to help reduce the stress on bones and the number of joint replacement surgeries needed. The solution to these problems might lie in the biomechanics of 3D printing cell-laden hydrogels.

A hydrogel is a web of polymer chains that is composed of 90 percent water. These gels are highly customizable and can be made



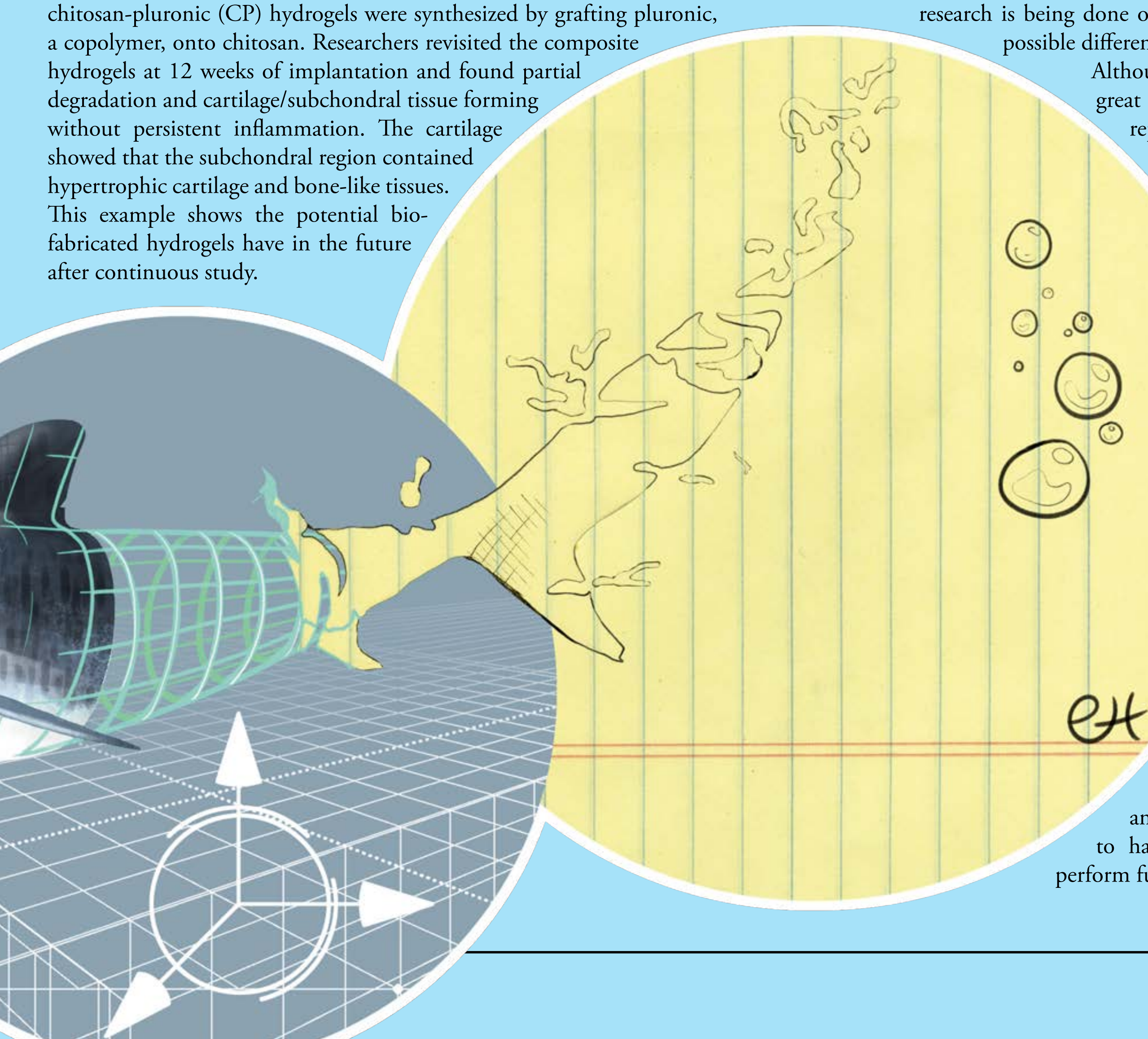
with either natural polymers (which are made from polysaccharides and proteins) like collagen, gelatin, and fibroin; synthetic polymers; or a hybrid of both. Natural polymer hydrogels have a low immune response, are biodegradable, and have a lower cost, but do not provide a stable long-term solution because the degradation of the material cannot be controlled. Synthetic fibers, however, exhibit highly modifiable biodegradability, biocompatibility, mechanical properties, and biochemical characteristics, due to the ability to tune their chemical structure and molecular composition. However, synthetic fibers can also lack cell recognition sites, which can affect cell communication, adhesion, and growth. By compounding natural and synthetic fibers together, researchers can create a highly modifiable substance that is compatible with the human body. One popular natural biopolymer is chitosan. Chitosan, which is derived from chitin, is the second most abundant biopolymer in nature. It is found in shells, insect cuticles, and even mushroom envelopes. A chitosan solution, when mixed with cells, provides a successful printing and is stable under simulated physiological conditions. Researchers observed that cells printed within chitosan-HA composite hydrogel had high expression levels for early and late stages of bone-forming indicators. During a clinical test, thermosensitive chitosan-pluronic (CP) hydrogels were synthesized by grafting pluronic, a copolymer, onto chitosan. Researchers revisited the composite hydrogels at 12 weeks of implantation and found partial degradation and cartilage/subchondral tissue forming without persistent inflammation. The cartilage showed that the subchondral region contained hypertrophic cartilage and bone-like tissues. This example shows the potential bio-fabricated hydrogels have in the future after continuous study.

> By compounding natural and synthetic fibers together, researchers can create a highly modifiably structure that is compatible with the human body.

Bio-fabrication is a process of interweaving cellular and noncellular components to mimic the composition and function of the human tissue. This process could be combined with microcarrier technology, which allows for an expansion of cells while they aggregate and allows for a controlled phenotype. Based on their function and desired host, microcarriers can be placed into one of two categories: solid or liquid. Solid microcarriers are used in humans due to their ability to adhere to and expand cells. Liquid microcarriers, meanwhile, have been used in animals, do not need a specific attachment point, and can be implemented without the use of a scaffold, which is a fibrous structure that is seeded with cells and growth factors to help facilitate healing or growth in a specific area.

For cartilage regeneration, growth factors such as TGF-ß (transforming growth factor) are added to help the differentiation of stem cells in the hydrogel. Too much growth factor, however, can lead to excess hypertrophy. These growth factors can be delivered by freeform in a medium, physical blending in the hydrogel, covalent bonding to the hydrogel, microsphere carriers, or by gene delivery. Tissue engineering and clinical treatments still have not been able to create a tissue that is fully functional. Inkjet bioprinting has the potential to mimic the structure of cartilage without causing more damage to the surrounding area. When using thermal inkjet printers, ink droplets are discharged by tiny heated air bubbles at 300˚C for a few microseconds, and the cells are then heated for 2 microseconds, which is 4–10˚C above the normal cell viability level. In a test hydrogel, chondrocytes, which are mature cells that create the matrix of cartilage, were seeded and displayed viabilities of 90 percent. Although chondrocytes show promising results, more research is being done on the long-term growth and possible differentiation into fibroblasts.

Although this is not yet a reality, great strides are being made to repair cartilage defects and regenerate cartilage. Medical grade cartilage may take 10–15 years to become a surgical option, but this is the closest the scientific community has come to creating a vital substance made out of your own body. Stem cells are even more promising for their availability and potential to turn into chondrocytes or osteoblasts. The ultimate goal is to create the best hydrogel; it should have a controlled biodegradability and be able to be regenerated to have a natural structure and perform full cartilage function.



What's Cooking?

Climate Change, Legislation, and Growth

Written by Leo Lasdun
Illustrated by Lydia Newman-Heggie

What is always interesting to look for when a new administration takes office is a pointed shift in priorities. When Donald Trump was first elected, it was unclear how this shift would manifest itself, but it was certain that Obama's commitments to environmental sustainability and improvements in clean energy would fall by the wayside, supposedly in order to aid business growth in the oil and coal mining industries. With a president who denies the existence of climate change, conservatives dominating every branch of government, and an ever-increasing American obsession with growth and consumption, the environment is facing unprecedented challenges.

Under the Obama administration, the United States made strides towards becoming a global leader in sustainability and progressed towards energy independence. The American Recovery and Reinvestment Act dedicated $90 billion in funds towards clean energy investments, and the administration sponsored initiatives for increased access to solar energy in low-to-middle income communities. Obama also targeted carbon emissions by tightening efficiency standards for appliances and creating new regulations for carbon pollution from power plants.

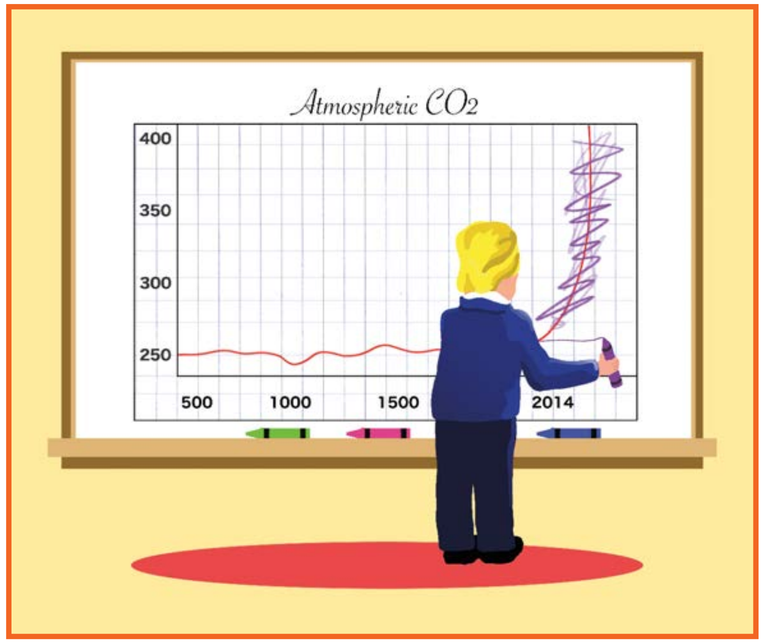
In the fight for environmental protection, legislation is the greatest weapon. Since Theodore Roosevelt established the protection of National Parks, legislation has been used to conserve our natural resources. Unfortunately, as is now abundantly clear, legislation is a double-edged sword. Donald Trump's disregard for the well-being of the planet has made an impact less than a year into his term, most notably with his withdrawal from the Paris Climate Accords. He's also ramped up leasing for areas in the Gulf of Mexico for oil and natural gas drilling and fired a slew of Environmental Protection Agency (EPA) scientists.

But the bulk of Trump's environmental destruction has been scrapping the work of his predecessor. The list of programs, committees, and regulations he's thrown out is already extremely lengthy. Some of his most abhorrent actions include the discontinuation of a study on the public health risks associated with mountaintop removal, the move toward a repeal of the Obama-era Clean Power Plan, scrapping the "Stream Protection Rule" allowing mining waste to end up in streams and rivers, and signing off on massive cutbacks in important protections for endangered species, such as whales and grouses.

We've started to see results, not just of Trump's legislative purge, but of a longstanding indifference to the way we treat the planet. A veritable flock of hurricanes has ripped through the Atlantic, ravaging Puerto Rico, Texas, and Florida. Donald Trump has completely ignored his responsibility to Puerto Rico as a U.S. territory, leaving the historically disadvantaged island to bear an unfair proportion of the brunt of climate change. In Texas, Hurricane Harvey caused $200 billion in damages, even more than Katrina's $160 billion. The wetlands that once existed around Houston would have absorbed a significant portion of flood water and saved millions of dollars had they not been paved over to make way for urban sprawl.

When looking at environmental legislation, it's important to examine trends that might impact public opinion on the environment. Has there been an increase in natural disasters? Have gas prices fluctuated irregularly? Are we suddenly able to light our drinking water on fire? These kinds of things, one would hope, draw the attention of the public away from the multitude of other concerns we all have, and encourage some momentary foresight into the future of the planet.

But the election of a president who consistently rejects the overwhelming consensus by the scientific community on climate change is indicative of a serious lack of foresight on the part of the American people. It's not a blind spot either; according to the *Yale Program on Climate Change Communication*, 70% of adults in the United States



believe global warming exists. But the same study also concluded that only 40% of American adults believe that global warming will harm them personally, which is where problems begin to arise.

With a process as gradual as climate change, it's hard for any individual to perceive an immediate risk. Of course, with millions of citizens living in poverty, it's even harder to get people worked up about icebergs melting halfway across the globe. People are struggling to put food on the table, so of course the issues of employment and social welfare will generate much more collective American angst than climate change. It's easy to place the blame for global warming on the apathy of citizens and corporate greed. But while these factors, and a plethora of others, are undoubtedly responsible in one way or another, at the root of the problem is an actively unhealthy and unsustainable mindset.

Since the industrial revolution, we Americans have become increasingly fixated on growth. On the individual level we are obsessed with consumption, which fuels rampant corporate expansion, driving up production of more and more stuff, which will inevitably feed back into the vicious cycle. We assume that potential for growth is infinite, and that we can continue to externalize the consequences of our material lust forever. But if we don't try to rid ourselves of this dangerous mindset soon, the comfort of denial will become insufficient. We need to face the reality that the lives we've grown used to are unsustainable, and we need to do it now.

Time for an Upgrade

The Shift to 3D Printed Casts

Written by Nathalie Weiss
Illustrated by Jack Bens

When you hear the word "cast," what first comes to mind is probably an itchy mass of hardened bandages covered in plaster. Although as a kid it can be fun to get signatures on this bulky sleeve, as an adult, casts can be more troubling. They restrict motion, create itching skin, and must be bagged before entering water. Aside from these minor nuisances, casts can also cause serious medical issues for their wearers. Plaster splints and casts are made of a highly hygroscopic material, which is a substance that absorbs moisture from the air. This property can cause infections and ulcers that can, in rare cases, lead to amputations. Hygroscopic materials absorb sweat, creating an ideal environment under the cast for bacteria to flourish due to the lack of ventilation. Luckily for the modern human being, tests are being done to create 3D-printed casts that are lighter in weight, heal bones more quickly than traditional casts, and are permeable. A result of an experiment that has generated great interest across the scientific community, these casts will be made of permeable, waterproof, and custom-sized plastic.

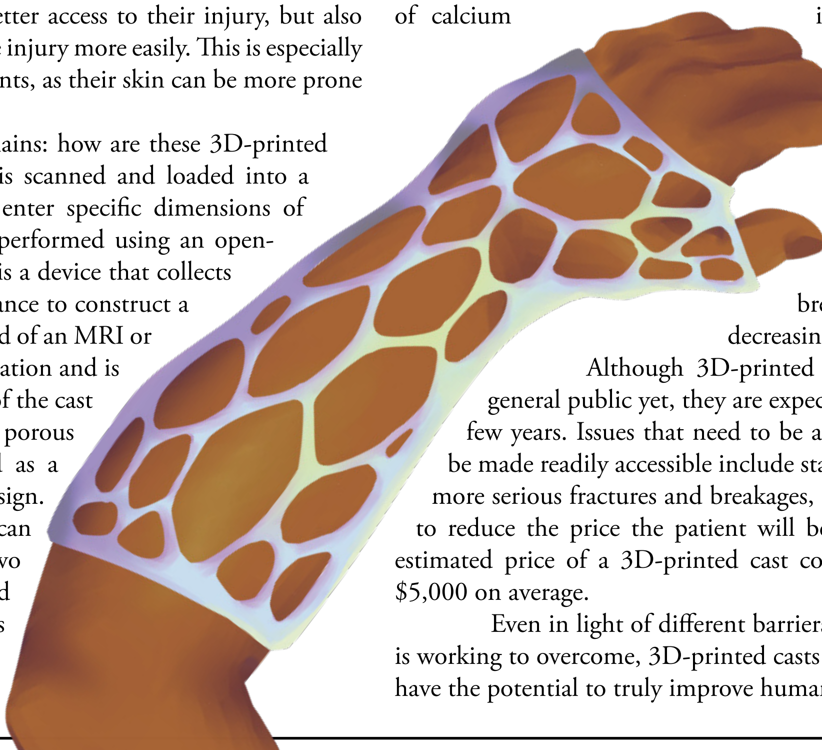
The invention of 3D-printed casts means no more smelly plaster or struggling with an ill-fitting mass of bandages. The 3D-printed casts are lightweight and preliminary testing has shown that they will be able to allow bones to heal significantly faster than traditional casts. While traditional plaster casts are not recyclable and contribute to the large amount of medical waste disposed of each year, 3D-printed casts are recyclable after each use. Furthermore, the open-lattice plastic design of the cast allows the skin underneath to breathe and prevents odor from forming due to trapped sweat. The open spaces in the plastic are large enough to use one's fingers to itch the skin underneath as well. The design of the cast not only gives patients better access to their injury, but also allows doctors to redress and assess the injury more easily. This is especially helpful when dealing with older patients, as their skin can be more prone to tearing.

However, one question remains: how are these 3D-printed casts made? First, the broken limb is scanned and loaded into a computer where the physician can enter specific dimensions of the patient's limb. This scanning is performed using an open-air photogrammetric scanner, which is a device that collects data on an object's shape and appearance to construct a 3D model. This scanner is used instead of an MRI or CT scan because it can eliminate radiation and is more cost-effective. The dimensions of the cast are then tweaked and printed with a porous plastic material. The cast is printed as a two-dimensional two-piece lattice design. Heat is applied to the print so that it can be molded to the broken limb. The two pieces are laid on the patient's limb and connected by a snap-fit clip, which is designed to permanently lock into place and has a flat ledge to prevent disassembly.

One drawback of these 3D-printed casts is the amount of time necessary to initially create them. The 3D printing of the cast takes an average of three hours to execute, while a plaster cast can be made in approximately three to nine minutes. However, even though it can be made at a faster speed than a 3D-printed cast, traditional casts take 24–72 hours to fully set. Setting is the time period in which the plaster and water mix to form gypsum, a sulfite mineral that makes up one of the main components of the set plaster. 3D-printed casts, on the other hand, do not require time to set.

3D-printed casts that emit ultrasound pulses can increase recovery time by 80% for fractures where the bone is completely separated.

In terms of a quicker healing process, ultrasound pulses can be combined with 3D-printed casts to speed up recovery time. Dr. Michael Hausman and Dr. Clinton Rubin, surgeons at Mount Sinai Hospital in New York City, researched the impact of ultrasounds on healing broken bones. The Osteoid is a 3D-printed cast model developed by industrial designer Deniz Karasahin that when connected to a low-intensity pulsed ultrasound for twenty minutes a day, sped up the healing process by 28% as compared to the healing process associated with a traditional plaster cast. 3D-printed casts that emit ultrasound pulses can increase recovery time by 80% for fractures where the bone is completely separated. The benefits of the ultrasound pulses come from increasing the incorporation of calcium ions in both cartilage and bone cells. Ultrasound pulses cannot easily be applied to traditional plaster casts because the probes need to be directly attached to the skin of the patient, which would require physicians to make breaks in the plaster casts, thus decreasing their stability.



Although 3D-printed casts are not available to the general public yet, they are expected to be ready within the next few years. Issues that need to be addressed before these casts can be made readily accessible include startup cost coverage, support for more serious fractures and breakages, and access to cheaper materials to reduce the price the patient will be required to pay; the current estimated price of a 3D-printed cast could be anywhere from $200–$5,000 on average.

Even in light of different barriers that the scientific community is working to overcome, 3D-printed casts have a long list of benefits that have the potential to truly improve human lives and increase comfort.

Lab-Gro

Food Savior of The Futur

Written by J
Illustrated by

One afternoon in London, an audience saw something like a movie scene unfurl before their eyes. A lab-grown burger was unveiled, cooked, and eaten in front of the crowd, and was broadcasted internationally as well. This event not only proved the feasibility of the experimental foodstuff, but accelerated research thereof, and increased interest in lab-grown meat.

Lab-grown meat, also called "cultured" or "in vitro" meat, consists mostly of skeletal muscle containing a variety of cell types. This combination of cells is made possible by the combination of proliferation, differentiation, and fusion techniques. Through experimentation, researchers have found that each proposed cell type for producing in vitro meat—embryonic stem, myosatellite, and adult stem—has its own set of advantages and disadvantages. Embryonic stem cells have infinite regenerative capacity, yet are prone to genetic mutations that could restrict production. Some adult stem cells hold the ability to transform into one specific cell, and some into a multipotent cell. Certain adult stem cells can differentiate into a specific type of cell, such as an epithelial stem cell, which could form muscle. Others, like adipose tissue-derived adult stem cells, are multipotent, meaning they can develop into more than one cell type, but their susceptibility to malignant transformation prevents usage of this cell type. Myosatellite cells form a rare muscle

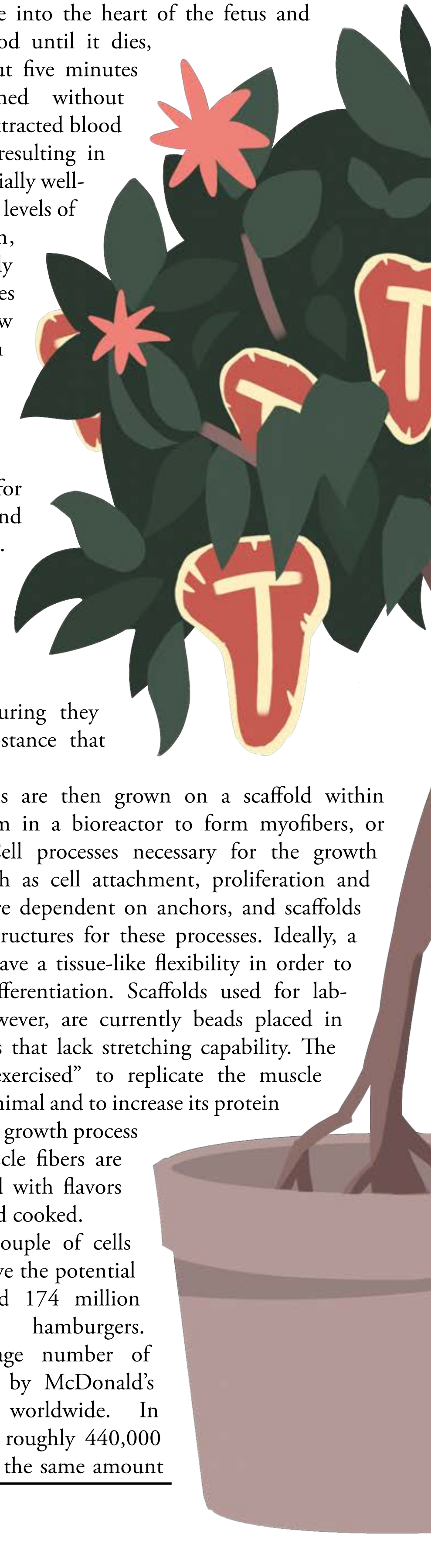
> Just a couple of cells from one cow have the potential to spawn around 174 million quarter-pound hamburgers.

tissue with limited regenerative capabilities, but are considered the best cells for cultured meat due to their efficiency in repeating myogenesis (the formation of muscle tissue during embryonic development). These cells are the most popular choice for the production of in vitro meat. Once myosatellite cells are extracted from the animal, a growth serum is added in order for the cells to multiply and grow into lab meat.

The growth stimulant used is called fetal bovine serum. Fetal bovine serum (FBS) is a commonly used animal cell culture medium, though the method of retrieving FBS has often come under attack for being inhumane and unethical. In order to obtain FBS, live fetuses removed from pregnant cows in the dairy industry undergo cardiac puncture—a process that involves inserting a needle into the heart of the fetus and draining the blood until it dies, which takes about five minutes and is performed without anesthesia. The extracted blood is then refined, resulting in FBS. FBS is especially well-known for its low levels of immunoglobulin, an antibody that neutralizes pathogens. Low immunoglobulin lessens the chance of these antibodies mistaking bovine cells for a pathogen and destroying them. The growth factor in FBS helps prevent the cultured bovine cells from dying, ensuring they grow into a substance that replicates meat.

The cells are then grown on a scaffold within a culture medium in a bioreactor to form myofibers, or muscle fibers. Cell processes necessary for the growth of lab meat, such as cell attachment, proliferation and differentiation, are dependent on anchors, and scaffolds function as substructures for these processes. Ideally, a scaffold should have a tissue-like flexibility in order to stimulate cell differentiation. Scaffolds used for lab-grown meat, however, are currently beads placed in rotary bioreactors that lack stretching capability. The cells must be "exercised" to replicate the muscle texture from an animal and to increase its protein content. After the growth process is complete, muscle fibers are pulverized, mixed with flavors and nutrients, and cooked.

Just a couple of cells from one cow have the potential to spawn around 174 million quarter-pound hamburgers. That's the average number of hamburgers sold by McDonald's every month, worldwide. In contrast, it takes roughly 440,000 cattle to produce the same amount



wn Meat

e or an Elusive Ambition?

ayla Johnson
Emily Herrold

of beef. Lab-grown meat would not only utilize around 90 percent less land and 70 percent less energy in comparison to current cattle farming methods, but also help decrease air and water pollution and waste associated with animal farming techniques. It could eradicate meat quality inconsistencies and the possibility of foodborne illness. These possibilities are what continue to inspire Dr. Mark Post and his team at Maastricht University to continue researching cultured meat. After his live taste reveal of the first cow-less burger in London in 2013, Dr. Post has become the public face of lab-grown meat. He hopes that by the year 2020 it won't be strange for consumers to purchase in vitro burgers for $10. Privately funded by a Google co-founder, Dr. Post and his team are working on producing a burger without using an animal-derived growth medium, growing fat tissue separately for added flavor and texture, and using oxygen levels to influence the color of the meat (meat's color comes from myoglobin, a protein that turns red in the presence of oxygen). His

> Lab-grown meat helps decrease air and water pollution and waste associated with animal farming techniques.

burger costs $350,000 to produce due to the technology expenses, but he's optimistic that the price will decrease as the process becomes more efficient. As other researchers work at finding faster, more cost-effective methods of growing meat, Dr. Post has confidence that in vitro meat dishes will become as commonplace on a menu as animal-based ones.

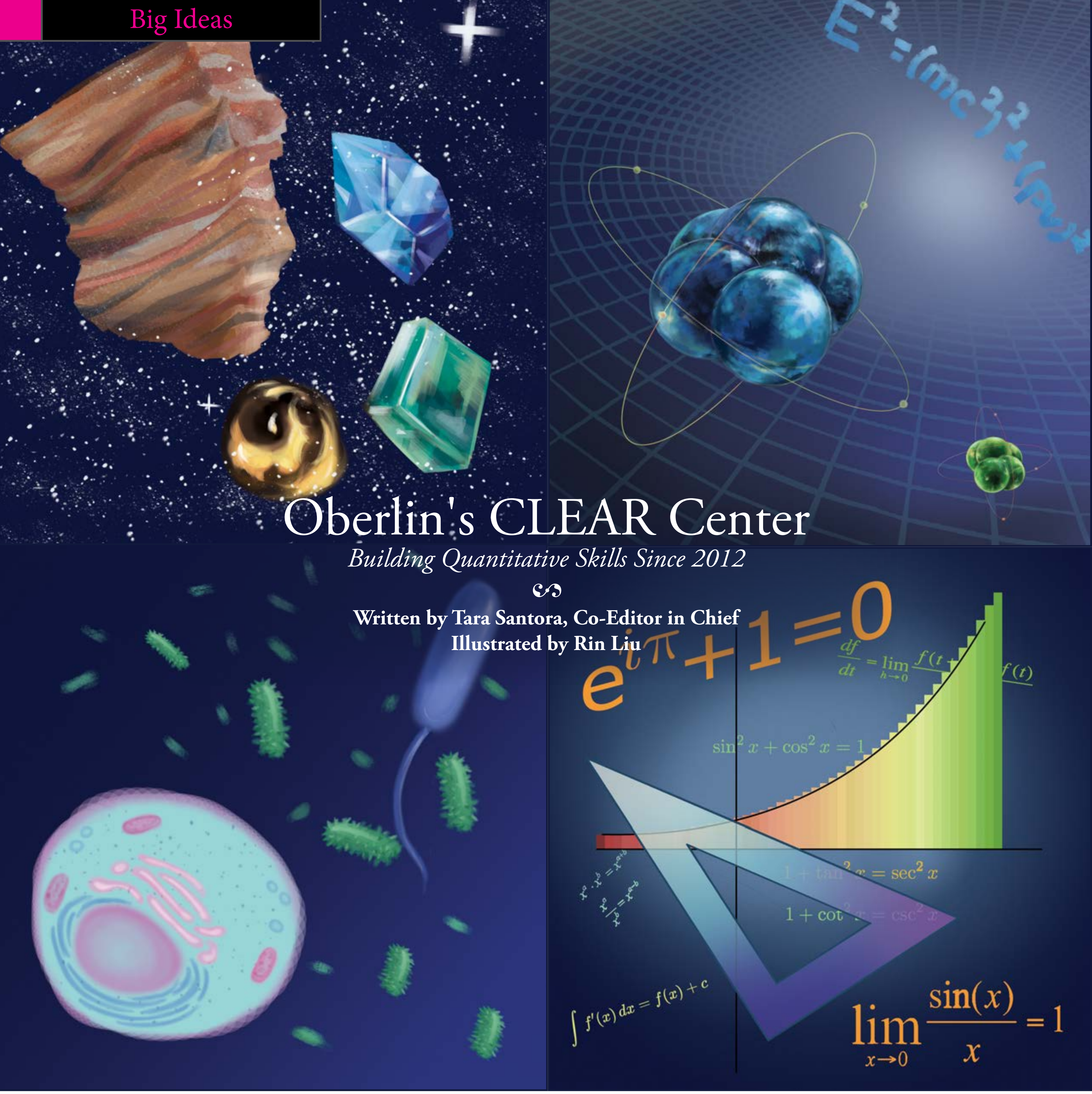
Cultured meat could help reduce environmental suffering, but it isn't without its own costs. Christina Agapakis, a synthetic biologist at University of California–Los Angeles, says cell cultures are one of the most expensive and resource-intensive meat bases in biology, and a large amount of labor and energy is necessary to ensure the cells remain warm, alive, fed, and protected. Dr. Agapakis reminds us that reliance on FBS, a byproduct of cattle farming, undermines the entire purpose of cultured meat. Therefore, cultured meat isn't helping to destroy slaughterhouse industries, but instead is relying on them to create FBS. While researchers, including Dr. Post, experiment with non-animal derived growth stimulants, such as algae, they're much more expensive than FBS. Skeptics of in vitro meat argue that the true allure of cultured meat is its seemingly easy solution to a larger problem at hand—the inequality of food distribution worldwide and the strain of heavy global meat consumption.

There are numerous arguments for and against cultured meat, but most agree that the biggest hurdle is actually convincing people to eat it. Even if enough cultured meat could be produced easily, ethically, and at an affordable price, the idea

> Lab-grown meat utilizes 90 percent less land and 70 percent less energy in comparison to current cattle farming methods.

of consuming a product grown within a lab is still often viewed as an unsettling prospect. The support and investment of billionaires and large corporations, including Bill Gates, Richard Branson, agricultural company Cargill, and capital firm DFJ, are, even unintentionally, helping to desensitize and normalize lab-grown meat. By giving their support to companies and researchers working to perfect in vitro meat, they not only inspire startup companies in the cultured meat arena such as Good Food Institute, Hampton Creek and Memphis Meat, but publicize the idea that consuming in vitro meat should be expected in the near future.

In the past, the appeal for lab-grown meat stemmed more from curiosity than urgency. With the onset of climate change, as well as a rapidly growing population, the question of food availability has resurfaced. The curiosity in lab-grown meat has returned at a time when the world's food supply is in jeopardy due to climate change and population growth. Will lab-grown meat become the new normal? Are we heading towards a world that will rely on food grown in petri dishes? Is this even the best solution? As researchers continue to work toward answers, only time will tell.



Oberlin's CLEAR Center

Building Quantitative Skills Since 2012

Written by Tara Santora, Co-Editor in Chief
Illustrated by Rin Liu

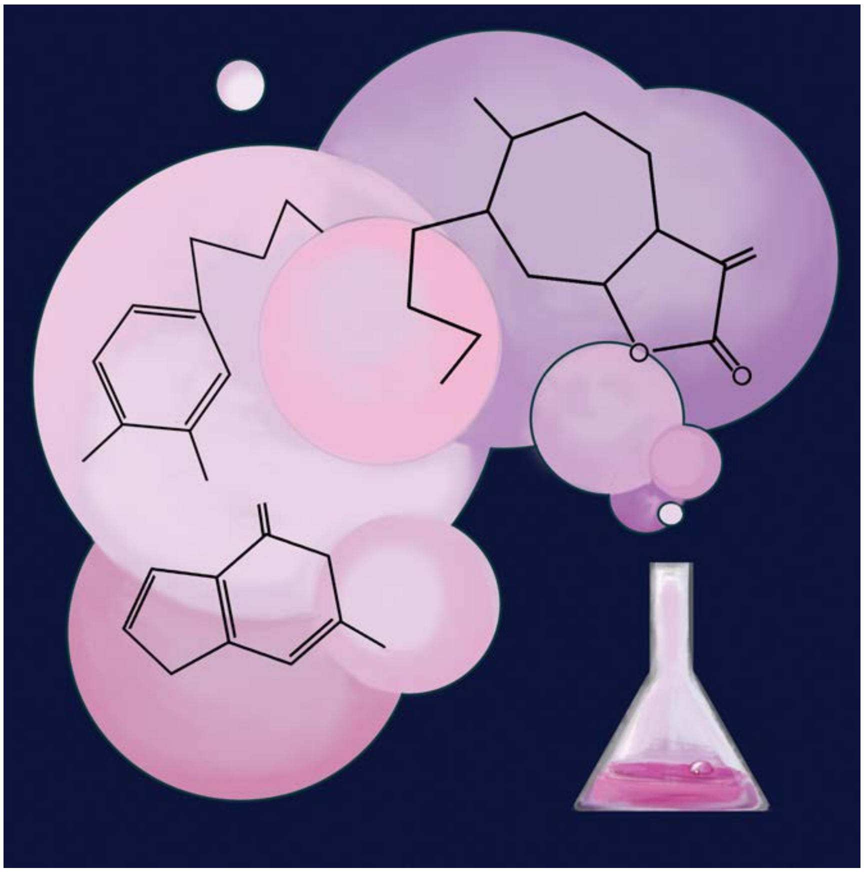
It's the night before my lab report is due, and I have *no idea* how to calculate the micrograms of acid phosphatase in my extract. I try to call my lab partner, but she doesn't pick up the phone. I bite nervously on the end of my pencil. I can't figure this out alone.

Luckily, I don't have to. I shove my lab notebook and calculator into my backpack and head to the Quantitative Skills Center, a part of the Oberlin CLEAR Center. I slide the door open sheepishly, but my fear of asking for help disappears as a drop-in tutor groans about how they hated this lab too and hunkers down to help.

Oberlin's Center for Learning, Education, and Research in the Sciences (CLEAR Center) was founded in 2012 when the College was awarded a Howard Hughes Medical Institute (HHMI) grant of $800,000. One of the goals of the grant, and thus the CLEAR Center, is to promote the achievement and retention of students, especially underrepresented students, in science, technology, engineering, and mathematics (STEM). Since 1920, graduates from Oberlin College have gone on to earn more PhDs in science and engineering than students from any other liberal arts college in the United States. Oberlin wants to keep this trend going and to help underrepresented students become a larger, fairer proportion of these PhDs.

What is the CLEAR Center? It is not a physical place, and it cannot be reduced to one program or goal, which makes the Center difficult to define. The CLEAR Center, founded by former director Marcelo Vinces, hosts several programs, talks, and events each year, each with the goal of supporting students in the sciences. Perhaps the most widely known program on campus is Oberlin Workshop and Learning Sessions (OWLS). Several STEM classes have OWLS, which typically hold the form of two hour-and-a-half sessions per week led by two students who took the course in the past. OWLS are designed to encourage active and collaborative learning in a fun and low-pressure environment and to support students who learn in ways that may not be catered to during lecture classes.

Some OWLS sessions are based on worksheets while others may feature Jeopardy review games or Q&A sessions. No matter the format, OWLS sessions are designed to reframe course material in easily understandable and sometimes goofy ways. One Introductory Chemistry OWLS session is famous for balancing chemical reactions using Skittles (and eating the treats once you find the correct answer). OWLS gives students who are struggling in class the chance to ask questions and gives students who feel confident with the coursework an opportunity to solidify their understanding by explaining concepts to their peers.



Not only does the OWLS program support students, but it also allows student teachers to learn and practice how to be effective educators and moderators. Speaking as a former Introductory Biology OWLS leader, I greatly benefited from learning how to explain tricky concepts and how to design worksheet problems that build critical thinking skills. As a complete biology nerd, I also savored the chance to get new students excited about all things biology.

A program led by the CLEAR Center that assists a broader range of students is the Quantitative Skills (QS) Center. Drop-in tutors at the QS Center are available weeknights at the Science Center Library and Mudd Library to assist with a variety of questions. Of course, quantitative skills are necessary for subjects as varied as physics to economics, so the QS Center is in no way limited to STEM students. Tutors are trained to help with everything from problem sets to lab reports to Microsoft Excel assignments. Social sciences and humanities students working with quantitative materials or technology are welcome to drop by!

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Oberlin's CLEAR Center also features science-related events throughout the semester. One yearly favorite is Lab Crawl, where professors across disciplines, including the social sciences and humanities, open their labs for curious students to see what they do and ask questions. Lab Crawl makes student and faculty research more visible on campus and helps prospective student researchers find faculty mentors. Another high-profile event hosted by the CLEAR Center is the Celebration of Undergraduate Research, which allows students to present their research in either a poster session or oral presentation and commemorate the accomplishments of their peers.

The CLEAR Center is not only about STEM; one of its major goals is to increase interdisciplinary learning. One way the program does this is through its Roots & STEM series, which focuses on the human elements of science and technology and is co-sponsored by the College's Gender, Sexuality, and Feminist Studies department and the Multicultural Resource Center. Past events have included a Celebration of Black Scientists and a Symposium on Science, Social Engagement, and Social Justice.

Although the original HHMI grant has now run dry, Oberlin was recently awarded a new 5-year, $1 million HHMI Inclusive Excellence grant to change how science is constructed and taught at the College. The forthcoming changes will be designed to improve the learning experiences of science students from diverse backgrounds.

A student-focused academic resource such as the CLEAR Center cannot be run without dedicated and visionary faculty. When the CLEAR Center began in 2012 with its first HHMI grant, Marcelo Vinces became the founding director. After his and others' tireless work and dedication to CLEAR, which led to the attainment of the $1 million HHMI grant, Marcelo will be leaving Oberlin. We at *The Synapse* wish him luck with his future endeavors, and welcome the new CLEAR director with excited anticipation of what they will bring to our scientific community.

As a QS Center tutor and former OWLS leader, I have seen the CLEAR Center resources and events not only help students with their coursework, but increase their confidence and faith in STEM. The CLEAR Center reminds us that science is not a solitary activity but a communal one, that it's okay to ask for help, and that peers are friends, allies, and study buddies—not competition. ●

Oberlin's Quantitative Skills Center has drop in hours in 1st floor Mudd and the Science Library Sunday-Thursday from 9-11 pm. Visit the following website for more information: http://new.oberlin.edu/office/clear/for-students/drop-in-tutoring/index.dot.

Marcelo Vinces

By Victoria Albacete, Co-Editor in Chief
Illustrated by Lily Jones

A native of Ecuador, Marcelo Vinces is primarily the director of CLEAR, the Center for Learning, Education, and Research in the Sciences, at Oberlin College. He also serves as the Associate Director of the Center for Teaching Innovation and Excellence (CTIE) and retains a position as a Visiting Assistant Professor in Oberlin's Biology department. Growing up in New York City, he attended Brooklyn Tech High School and proceeded to earn his undergraduate degree from Cornell University in Ithaca, NY. He received his Ph.D. in Microbiology from Tufts University in Boston, MA and continued his postdoctoral studies at Harvard University, later moving to Belgium with the Harvard laboratory. Vinces has been a part of the Oberlin community for nearly half a decade, and will be departing to pursue other opportunities in Chicago at the end of the fall 2017 semester. We at The Synapse *thank him for his constant support for the magazine throughout his time in Oberlin—in fact, he was previously interviewed by* The Synapse *about his work with the CLEAR Center—and wish him all the best in his future endeavors!*

This interview has been edited for length and clarity.

We last interviewed you for *The Synapse* in May of 2015, so it's been about two and a half years. That interview was mostly about the CLEAR Center, which was only about two years old at that point. So how has CLEAR changed and grown in the past two and a half years?

It's changed so much, and it's so interesting because one of the ways it's changed is that it's grown. It's basically me as a full-time person and we have a part-time administrative assistant, but now I have a colleague—Nicolette Mitchell, who's a STEM Fellow—so now there's the two of us!

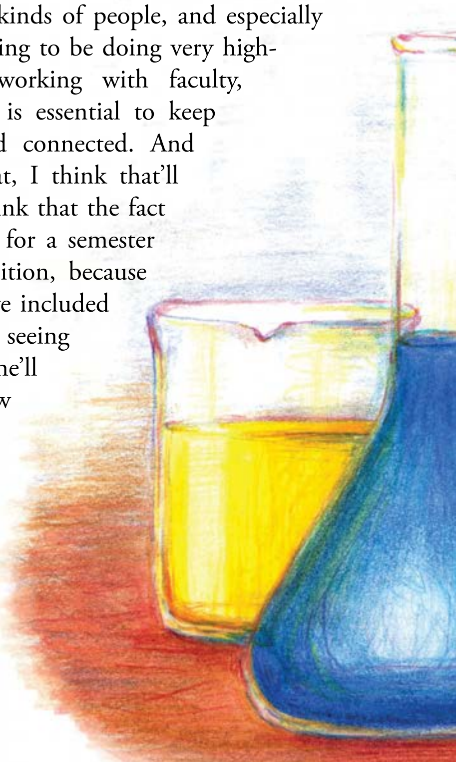
Some unexpected things about starting a science center at Oberlin is that even though it had a very focused mission of supporting quantitative skills and interdisciplinary learning, and specific programs like OWLs and the Quantitative Skills Center, we ended up being the go-to office for a lot of collaborations with the [Allen Memorial] Art Museum; with the Gender, Sexuality, and Feminist Studies department (GSFS); with the Multicultural Resource Center (MRC), and that has been great, especially now that we have a new grant because this new grant's mission is diversity in STEM. It's no longer this side project, this is what the center is about, and now we have more money, we have a different position—and that makes a big difference. Nicolette and I were talking about it, and she was saying that CLEAR is an appropriate [acronym] in that we are kind of like a clearinghouse for things, for connections—we're like a connector for things beyond just the science classroom.

I think that's become much more established. For example, this semester we've been getting a lot of emails asking "When's Lab Crawl, when's Lab Crawl?" We moved it to the spring, but people are already used to it every fall, so I think that's a sign that people have come to expect it and it's part of the culture here, so that's great for a brand-new office. It's only been around for four years, and it's become part of the fabric of Oberlin.

Having looked back at the past two years, how do you see the CLEAR Center moving forward without you?

So right now we're actually in the search for the new director, and one of the things that I told the search committee is that this is an opportunity to—that they shouldn't try to find a Marcelo replacement—that really it's an opportunity to look at and reflect on what we've accomplished in the first four years and where we are now, and what would be good to move things forward. It's an opportunity to be able to bring someone with a skill set that maybe I didn't have; they may be able to take things up to a different level.

Having said that, I also asked them—and I've been asking students this too—what are the things that, at minimum, you want a director, regardless of their skill set and experience and knowledge, to have? I think one of the things that has come out loud and clear is the ability to engage with different kinds of people, and especially with students. Even if they're going to be doing very high-level administrative stuff or working with faculty, that engagement with students is essential to keep everything student-centered and connected. And I wholeheartedly agree with that, I think that'll come out in the interviews. I think that the fact that Nicolette and I overlapped for a semester is going to help with the transition, because she's my junior colleague and I've included her in as much as possible. She's seeing how everything operates, and so she'll actually be able to help the new person come into the transition. That's something I would also look for, someone that could work with Nicolette as—and future STEM fellows—a junior colleague, and as a mentor.



So, you're leaving! What are your plans for after Oberlin as of now?

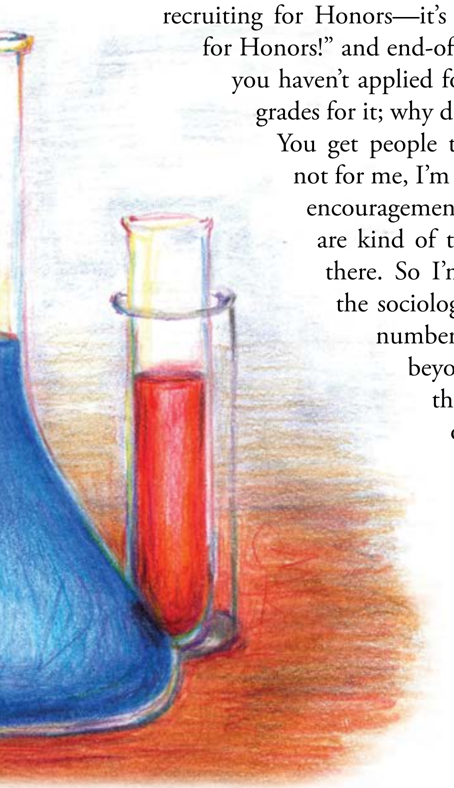
The only plan is to move to Chicago! My partner has moved for me many times for my career, including to Ohio; he was personally reluctant, and I was super excited because of Oberlin, but after four years, he felt like it was time for him to move. I'm excited about being in Chicago, especially because so many students I know here are from there, or they end up there! Every time I go to Chicago, I run into an Obie. Every single time! Or sometimes I plan it, like the last time I was in Chicago I met up with Mina [Huerta, OC '17]. So there are a lot of connections with Obies and I kind of want to continue that—I've actually told the Oberlin Latino Alumni Association (OLAA), "I'm not officially an Obie, but please consider me one, I will always do anything for current or former Oberlin students, I'm there for you in Chicago, I can help make connections, I have two guest rooms!" So I hope people visit, and I will definitely be back here for every commencement for the next however many years—there are freshmen that I've gotten to get to know really well and I want to be there for when they walk across the stage.

Speaking of knowing students and having a relationship with students, you've been really involved with the Latinx community on campus, and I was wondering how you see the presence and support for POC students in STEM growing—if that's happened—over the

past four years and how that's gotten better or stayed the same?

That's a really great and pertinent question right now for me because we collect a lot of data. And the data is something I would like to show to a much greater audience, because there's some good news: Over the last four years, the graduation of STEM majors who are from underrepresented groups has been steadily increasing to the point that we're almost above what you would expect from the demographics of the College.

So then the next thing to ask is why, right? What are the changes? Was it hiring, was it teaching practices, was it shifts in some processes that happened? Anecdotally, I just hear from different people about little things that are done; a faculty member in [the Mathematics department] was telling me that they've been more active in the way that they've been recruiting for Honors—it's not just an email saying "Apply for Honors!" and end-of-story, it's: "Hey, I've noticed that you haven't applied for Honors, and yet, you have the grades for it; why don't you try it?" And it has results! You get people that might otherwise say, "That's not for me, I'm not that student"—you need that encouragement, especially if societal messages are kind of telling you that you don't belong there. So I'm very interested in getting into the sociology and social psychology of these numbers that we're seeing—that's way beyond my expertise, it's something that Xavier Tirado [OC '17] kind of studied as both a Sociology and Biology major for his Sociology Honors thesis. I think it's a lot of rich information that we can dig into to understand what's going on.



Specifically with the Latinx community, I think there's a lot more activism with the different groups of students: the Black Scientists' Guild (BSG) is active again, they took a group of students to the Black Physicists' Society meeting; I know that the Computer Science [department], a lot of women went to a women in computer science conference. We're actually planning a social info session event where people talk about these conferences because it's important for even first years to know that those are opportunities, and they kind of nucleate community, even when they come back here. BSG got reactivated after one of these conferences; they came back and were just like, "Let's bring that group back."

You immigrated to the US from Ecuador as a child; do you still feel a strong connection to Ecuador? How do you think immigrating and being undocumented has shaped your experience in the US education system and particularly your experience in the sciences?

It's so complicated, and that relationship has changed over time. I'm very proud to be Ecuadorian American. I feel like I'm at a stage in my life both professionally and personally where I'm very comfortable in my skin, and I enjoy going to Ecuador even more now. I think there were periods in my youth where going to Ecuador was very disorienting, because I felt like neither here nor there, in the US I didn't feel American enough, and when I went to Ecuador I didn't feel Ecuadorian enough.

Now, I feel closer than ever to Ecuador; every time I go I reconnect with people I hadn't talked to in awhile—it's just great to know that I have family there. I think as a child and as an adolescent, I had complicated relationships with my identity and my education because I saw a lot of kids from my ethnicity devalue school; I was made fun of for getting good grades, I wasn't encouraged. So I kind of had this phase of rejecting my identity to the point where in college—I remember now with a lot of shame—someone trying to learn Spanish and asking me to help them and I was like: "No. I don't want to speak Spanish; no." To me it sounds so crazy now, because I love speaking Spanish and with a lot of my best friends, we just talk in Spanish; but I had that phase. And then to flip back, I had moments in high school where there were white people questioning my desire to want to be in science. Number one, my dentist! He was just like, "Oh you're going to go to college? That's interesting…" "Oh, biology? I don't know if you should do biology, it's very difficult." And I was just like, what is wrong with this man? He should be encouraging me and he's trying to talk me out of it!

So there were moments like that, but then for every one of those people, I had people who believed in me. I remember there was this nun, and she was white too, but first of all, in helping my family as undocumented people—she was a saint. With me and my brothers, [she'd say,] "You can do whatever you want," and was just very encouraging that way.

What do you hope to leave here behind at Oberlin?

I'm hoping [partnerships] will be sustained—like the Celebration of Undergraduate Research, a very tight partnership between the Office of Undergraduate Research and CLEAR. A lot of the science and society kind of events that have happened in collaboration with the MRC, or GSFS, or the art museum, I think that that should continue. The grant we got—obviously it was a very collaborative effort, but that is something I'm very proud of, and it's going to be here for the next five years. The idea is that it's going to have an impact on the college beyond the length of the grant, so the goal of it is to create sustainable institutional change and it'll be interesting, as I come back every commencement, to catch up with students. So yeah, I would hope that one day, Oberlin will be known, just as it's known for the Conservatory, just as it's known for environmental sustainability, as a place that students of diverse identities thrive in the sciences and go on to do great things.

Crossword Corner

BY RACHEL DAN

ANSWERS TO PREVIOUS PUZZLE

J	U	M	P		B	O	W	L		L	E	S	S			R	A	D	A	R
A	S	I	A		E	U	R	O		O	N	T	A	P		A	R	U	B	A
V	E	N	T		E	T	A	L		A	D	A	M	S		D	E	M	O	N
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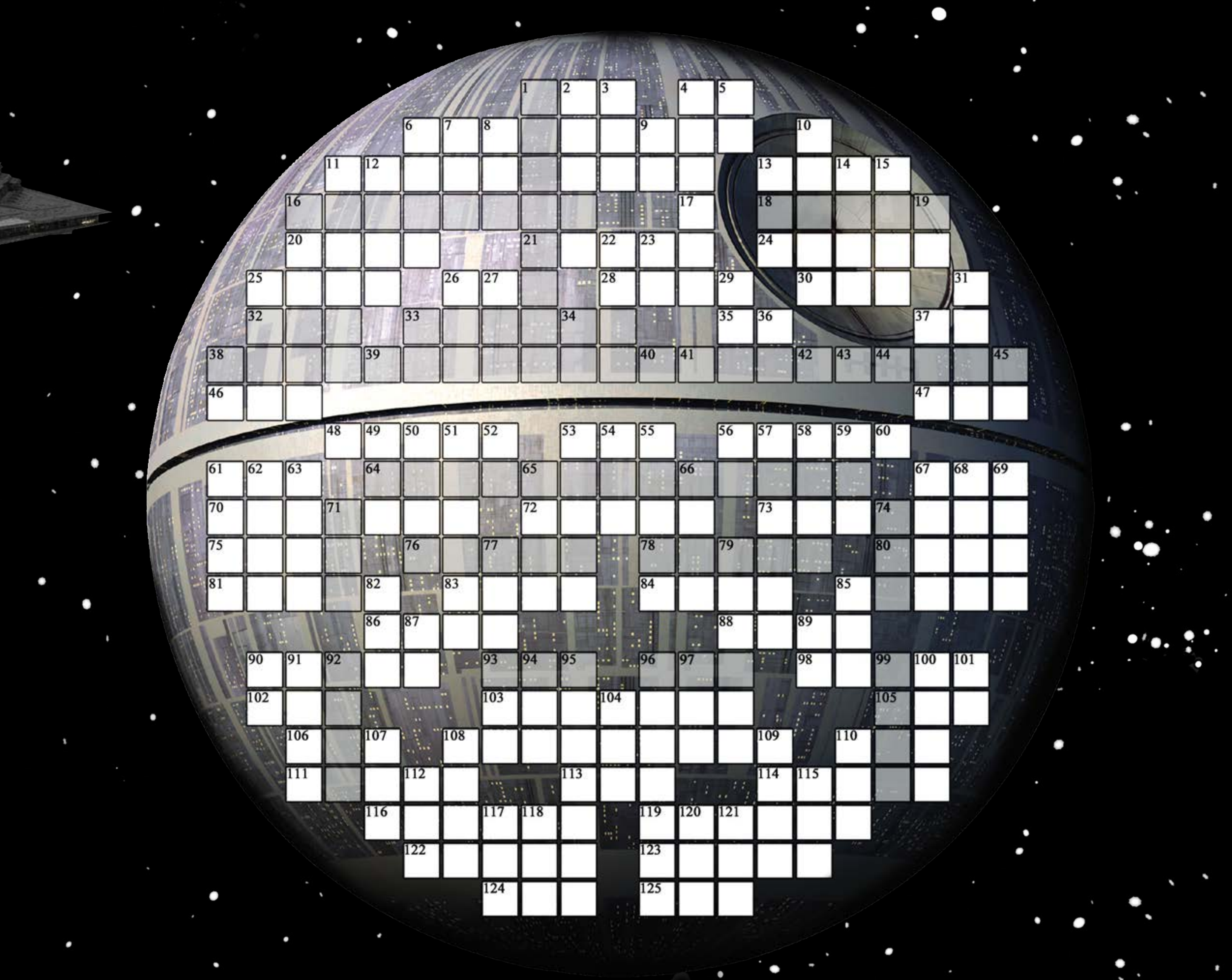
T	Y	P	E	D			E	D	D	Y		S	E	A	T		N	E	X	T

ACROSS

1 In short, awesome!
4 Author of *Synapse* article "If Cartilage Wears Away", inits.
6 Butterflies, in Bolivia
10 Symbol for electrical resistance
11 May be left at the altar
13 Luau decoration
16 Evil half of the Force
17 Cell cycle phase between G1 and G2
18 Kylo Ren's master in *The Last Jedi*
20 Killer whale
21 *Inglourious Basterds* antagonist
24 Nixon's VP
25 "Fire" brigade?
26 Film universe of *The Avengers*, abbr.
28 British noble rank
30 Japanese peninsula in Honshū
31 *Synapse* author Xu, first init.
32 Beatles hit: "Lucy in the ___ with Diamonds"
33 TV Texas Ranger
35 Dorothy's aunt in *The Wizard of Oz*
37 Director of *Avatar* and *Titanic*, inits.
38 Luke and Han's first adventure
46 Comedian Tina
47 Big attraction in London?
48 Large bowl for water
53 Kung ___ chicken
56 Pathos, ___, and Logos
61 It covers Pompeii
64 Big reveal of *The Empire Strikes Back*
67 Scientifically unverified 'sixth sense'
70 Type of comedian
72 Legally undo, as a marriage
73 Earthquake scale
75 Alternate name for Persephone
76 Not heavy
78 ___-toothed tiger (extinct cat)
80 Where Wile E. Coyote buys gadgets
81 What salmon do upriver
83 Type of chef
84 Bronte's "Jane ___"
85 Not groovy or cool
86 Bangkok banknotes
88 Polo goal?
90 Recovering addict's program, abbr.
93 Kimono sash
96 Pale and sickly
98 Edison´s rival
102 Start of a Latin 101 conjugation
103 Neighbor of Sweden
105 Well-gotten gain?



106 Package delivery service, abbr.
108 With 16-Across, a Pink Floyd album
110 "Right Round" rapper ___ Rida
111 "What ___ to be the problem?"
113 Cleopatra-killing snake
114 Tear-jerker
116 Self-confidence or composure
119 Baseball referee
122 ___ body (cell part)
123 Actress Kelly of "One Tree Hill"
124 Pro in first aid
125 House mate? (abbr)

DOWN

1 Leia's goal in *The Force Awakens*
2 Breathing problem for sleepers
3 Serpent that squeezes
4 Emperor's salad?
5 "Born in the U.S.A." singer, inits.
6 "Morning Joe" cohost Brzezinski
7 Commercials, for short
8 Big seller of outdoor gear
9 Chemical Samarium, abbr.
10 Drummer for the band in 32-Across
11 Person who dies for their beliefs
12 Story ___ (plot lines)
13 Search party?
14 With 16-Down, a Nintendo game
15 Swedish furniture store
16 With 14-Down, a Nintendo game
19 "Gross!"
22 Maker of foam darts and Super Soakers
23 Dopamine, abbr.
25 1975 Wimbledon champion Arthur
26 PC's rival
27 *TRON* antagonist
29 Hula dancer's necklace
31 Pubescent problem
33 Original Captain Kirk, inits
34 Prefix meaning 'early'
36 Illustrator of *Synapse* article "Nature vs Nurture", inits.
37 Boxer's blow
38 Dual copy and layout editor, inits (one of two in this issue)
39 Symbol for an electron
40 50, to Caesar
41 Symbol for a positron
42 Blood type
43 Author of this crossword, first init
44 Symbol for free energy in thermodynamics
45 Preposition
48 Inventor of the telephone, last init.
49 Financial ___ (scholarship)
50 Old Testament king
51 Prone to playing pranks
52 East Coast state
53 Football kicks
54 Schwarzenegger, to his pals
55 Helpful or handy
56 Movie alien who wants to phone home
57 Good things come in ___
58 Prince to a king
59 Servant of Mordor
60 *Synapse* cover artist, first init.
61 Enquires
62 Word shouted at a thief?
63 Samurai's ___-kiri
65 Pearl Harbor´s location
66 Indonesian slang
67 ___ A Sketch (classic toy)
68 Automatic starter?
69 Planning, for short
71 In mint condition
74 Chinese dynasty
77 Escaped punishment
79 Actor Marlon of *The Godfather*
82 Sports league with Kings and Wizards
85 Abu Dhabi's land, abbr.
87 Illustrator of *Synapse* article "The Fragile Helix", inits.
89 *Some Like __ Hot* (1950s film)
90 Egyptian sun god
91 Ostriches' look-alikes
92 2008 Obama slogan word
94 Tiny unit of data, or a drill part
95 To live in a place
96 Native American shell currencies
97 12 months, in Mexico
99 Song sung by one person
100 Safari creature
101 Element often used in foil, abbr.
104 ___ *Miserables*
107 Swell place?
108 Capital of Norway
109 Dark film genre
110 Archaic interjection
112 Car stat
115 Piece activists?
117 Spanish "hurray!"
118 Movie studio with a roaring mascot
120 Stooge with Larry and Curly
121 ATM request

/syn . apse/ noun : the point at which a nervous impulse passes from one neuron to another

The Synapse is an undergraduate science magazine that serves as a relay point for science-related information with a threefold objective. First, we aim to stimulate interest in the sciences by exposing students to its global relevance and contributions. Second, we work to bridge the gap between the scientific and artistic disciplines by offering students a medium through which to share their passions, creativity, and ideas. Third, we strive to facilitate collaboration between undergraduate institutions across the country, especially within the natural science departments.